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ASHRAE® STANDARD

AN AMERICAN NATIONAL STANDARD

Safety Code for Mechanical Refrigeration

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FOREWORD

A new version of one of ASHRAE's oldest standards, "Safety Code for Mechanical Refrigeration," has been issued in the Society's Centennial year. Rapid introduction of alternative refrigerants is necessary to make a timely response to environmental issues that challenge the air-conditioning and refrigeration industry. This edition of the "Safety Code for Mechanical Refrigeration" is written in code (nonpermissive) language to reduce the time for its implementation. ANSI/ASHRAE 15-1992 was used as the starting point for this edition.

This standard is directed toward the safety of persons and property on or near the premises where refrigeration facilities are located. It includes specifications for fabrication of tight systems but does not address the effects of refrigerant emissions on the environment. For information on the environmental effects of refrigerant emissions see ASHRAE Guideline 3-1990 and Addendum 3a-1992, "Reducing Emission of Fully Halogenated Chlorofluorocarbon (CFC) Refrigerants in Refrigeration and Air-Conditioning Equipment and Applications."

An additional objective of the committee was to make the document easier to use by grouping topics to assist the reader. The numbered paragraphs are separated into the following major topics:

General
Restrictions
Design and Construction
Operation and Testing

While the user must be familiar with the entire document, this major topic grouping allows quicker location of information. The subtopics included in these major groupings are:

GENERAL: Purpose, Scope, Definitions, Occupancy Classification, Refrigerating System Classification, Refrigerant Classification.

RESTRICTIONS: Restrictions on Refrigerant Use, Installation Restrictions.

DESIGN AND CONSTRUCTION: Materials; System Design Pressure; Refrigerant-Containing Pressure Vessels; Pressure-Relief Protection; Setting of Pressure-Relief Devices; Marking of Relief Devices and Fusible Plugs; Pressure Vessel Protection; Positive Displacement Compressor Protection; Pressure-Limiting Devices; Refrigerant Piping, Valves, Fittings, and Related Parts; Components Other than Pressure Vessels and Piping; Service Provisions; Fabrication; Factory Tests; and Nameplate.

OPERATION AND TESTING: Field Tests, General Requirements.

In the text of the standard, superscripts indicate the references included in Appendices D and E. Also, the notes included in the body of the standard are informative in nature and are not mandatory.

The principal changes in this version are:

Section 2—Revisions to the Scope for refrigerant changes after adoption and for parts replacement after adoption.

Section 4—Large Mercantile Occupancy added.

Section 5—Clarification of indirect open spray system.

Section 7—Rules rewritten for clarity and for applications of 100 horsepower or less.

Section 8—Air ducts through machinery rooms added and leak detector requirements revised.

Section 9—Added ASME code stamping, revised pressure test factor, added pilot-operated relief valves, added note for other heat sources to pressure-relief formula, added exception for hydrostatic relief valves, reworded section on ammonia discharge, revised rules for positive displacement compressor relief, and eliminated rule for mounting of stop valves under 0.875-inch diameter.

Section 11—Added lubrication identity and amount and revised requirements for storage of refrigerants in machinery rooms.

Table 1—Revised the quantities and footnotes.

Table 2—Removed rules 6 and 8 from Industrial Occupancy; revised use of rules 1 and 2 for high-probability systems.

A table with a paragraph number comparison of ASHRAE 15-1992 with this edition is in an informative appendix at the end of this document.

The hazards of refrigerants are related to their physical and chemical characteristics as well as to the pressures and temperatures occurring in refrigerating and air-conditioning systems. Personal injury and property damage from inadequate precautions may occur from:

Rupture of a part or an explosion with risk from flying debris or from structural collapse.

Release of refrigerant from a fracture, due to a leaking seal, or from incorrect operation.

Fire resulting from or intensified by burning or deflagration of escaping lubricant or refrigerant.

Personal injury from accidental release of refrigerants may also occur from:

Suffocation from heavier-than-air refrigerants in inadequately ventilated spaces.

Narcotic and cardiac sensitization effects.

Toxic effects of vapor or the decomposition products due to vapor contact with flames or hot surfaces.

Corrosive attack on the eyes, skin, or other tissue.

Freezing of tissue by contact with liquid.

Table 1 shows the amount of refrigerant in a given space that, when exceeded, requires a machinery room. When a refrigerant is not classified in ASHRAE 34-1992 or addenda or shown in Table 1, it is the responsibility of the owner of a refrigerating system to make this judgment. For blends, Appendix A is offered to aid in determining allowable concentrations.

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Care should be taken to avoid stagnant pockets of refrigerant vapors by proper location of ventilation inlet and exhaust openings (all commonly used refrigerants except ammonia [R-717] are heavier than air). All machinery rooms are now required to have detectors that will activate an alarm and mechanical ventilation at a value not greater than the corresponding TLV-TWA (or toxicity measure consistent therewith).

During public review of this standard, extensive comments were received from those interested in the use of ammonia as a refrigerant. The Society has established an ASHRAE Position Statement, "Ammonia as a Refrigerant," to which the reader is referred for positions in this regard. For more information on equipment, design, and installation of ammonia refrigerant systems, see ANSI/IIAR-2, published by the International Institute of Ammonia Refrigeration, Washington, DC 20036.

A short publishing history of this code traces the origins of these safety provisions. In 1919, the American Society of Refrigerating Engineers (ASRE) proposed a Tentative Code for the Regulation of Refrigerating Machines and Refrigerants. Over the next 11 years, representatives from the American Gas Association, American Institute of Electrical Engineers, American Institute of Refrigeration, American Chemical Society, American Society of Heating and Ventilating Engineers, American Society of Mechanical Engineers, National Electrical Refrigerator Manufacturers Association, National Fire Protection Association, and ASRE met to expand the code to address all of the issues raised on the use of refrigeration equipment. The first Safety Code for Mechanical Refrigeration, recognized as American Standard B9 in October 1930, appeared in the first edition, 1932-1933, of the ASRE Refrigerating Handbook and Catalog. ASRE revisions designated ASA B9 appeared in 1933 and 1939. ASRE revisions designated ASA B9.1 appeared in 1950, 1953, and 1958. After the formation of ASHRAE, editions appeared as ASA B9.1-1964, ANSI B9.1-1971, ANSI/ASHRAE 15-1978, ANSI/ASHRAE 15-1989, and ANSI/ASHRAE 15-1992.

1. PURPOSE

The purpose of this standard is to specify safe design, construction, installation, and operation of refrigerating systems.

2. SCOPE

2.1 This code establishes safeguards for life, limb, health, and property, and prescribes safety standards.

2.2 This code applies

(a) to mechanical refrigerating systems and heat pumps used in the occupancies defined in Section 4 and installed subsequently to adoption of this code; and

(b) to parts or components added after adoption of this code, or a change to a refrigerant of a different number designation (per *ANSI/ASHRAE Standard 34-1992*[4]) after adoption of this code; and

(c) to parts or components replaced after adoption of this code only if they are not identical in function.

2.3 This code does not apply where water is the primary refrigerant.

2.4 Equipment listed by an approved, nationally recognized testing laboratory is deemed to meet the design, manufacture, and factory test requirements section of this code for the refrigerant or refrigerants for which the equipment was designed.

2.5 The authority having jurisdiction has the authority to grant exceptions from the requirements of this code or allow, for local jurisdictional purposes, the use of other devices, materials, or methods when evidence is provided to demonstrate equivalent protection and performance.

3. DEFINITIONS

accessible: easy to approach for service or use (also see *readily accessible*).

approved: acceptable to the authority having jurisdiction.

approved, nationally recognized laboratory: one that is acceptable to the authority having jurisdiction, which provides uniform testing and examination procedures and standards for meeting design, manufacturing, and factory testing requirements of this code; is organized, equipped, and qualified for testing; and has a follow-up inspection service of the current production of the listed products.

blends: refrigerants consisting of mixtures of two or more different chemical compounds, often used individually as refrigerants for other applications.

brazed joint: a gas-tight joint obtained by the joining of metal parts with metallic mixtures or alloys that melt at temperatures above 1000°F (537.7°C) but less than the melting temperatures of the joined parts.

companion* or *block valves: pairs of mating stop valves that allow sections of a system to be joined before opening these valves or separated after closing them.

compressor: a machine used to compress refrigerant vapor.

compressor unit: a compressor with its prime mover and accessories.

condenser: that part of the refrigerating system where refrigerant is liquefied by the removal of heat.

condenser coil: a condenser constructed of pipe or tubing, not enclosed in a pressure vessel.

condensing unit: a combination of one or more power-driven compressors, condensers, liquid receivers (when required), and regularly furnished accessories.

containers, refrigerant: a cylinder for the transportation of refrigerant.

corridor: an enclosed passageway that limits travel to a single path.

critical pressure, critical temperature,* and *critical volume: a point on the saturation curve where the refrigerant liquid and vapor have identical volume, density, and enthalpy, and there is no latent heat.

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design pressure: the maximum pressure for which a specific part of a refrigerating system is designed.

dual pressure-relief device: two pressure-relief devices mounted on a three-way valve that allows one device to remain active while the other is isolated.

duct: a tube or conduit used to convey or encase: (a) *air duct* is a tube or conduit used to convey air (air passages in self-contained systems are not air ducts); (b) *pipe duct* is a tube or conduit used to encase pipe or tubing.

evaporator: that part of the refrigerating system designed to vaporize liquid refrigerant to produce refrigeration.

evaporator coil: an evaporator constructed of pipe or tubing, not enclosed in a pressure vessel.

fusible plug: a plug containing an alloy that will melt at a specified temperature and relieve pressure.

header: a pipe or tube (extruded, cast, or fabricated) to which other pipes or tubes are connected.

heat pump: a refrigerating system used to transfer heat into a space or substance.

highside: those portions of the refrigerating system that are subject to approximate condensing pressure.

horsepower: the power delivered from the prime mover to the compression device of a refrigerating system.

IDLH (immediately dangerous to life or health): the maximum concentration from which unprotected persons are able to escape within 30 minutes without escape-impairing symptoms or irreversible health effects.[1]

informative appendix: appendix that is not part of the standard but is included for information purposes only.

inside dimension: inside diameter, width, height, or cross-sectional diagonal.

internal gross volume: the volume as determined from internal dimensions of the container with no allowance for the volume of internal parts.

limited charge system: a system in which, with the compressor idle, the design pressure will not be exceeded when the refrigerant charge has completely evaporated.

liquid receiver: a vessel, permanently connected to a refrigerating system by inlet and outlet pipes, for storage of liquid refrigerant.

listed: equipment or materials included in a list published by an approved, nationally recognized testing laboratory, inspection agency, or other organization concerned with product evaluation that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

lobby: a waiting room or large hallway serving as a waiting room.

lower flammability limit (LFL): the minimum concentration of the refrigerant that propagates a flame through a homogeneous mixture of refrigerant and air.

lowside: the portion of a refrigerating system that is subjected to approximate evaporator pressure.

machinery: the refrigerating equipment forming a part of the refrigerating system including, but not limited to, any or all of the following: compressor, condenser, liquid receiver, evaporator, and connecting piping.

machinery room: a space, meeting the requirements of 8.13 or 8.14, that is designed to house compressors and pressure vessels.

manufacturer: the company or organization that evidences its responsibility by affixing its name, trademark, or trade name to refrigerating equipment.

means of egress: a continuous and unobstructed path of travel from any point in a building or structure to a public way.

mechanical joint: a gas-tight joint obtained by joining metal parts with a positive-holding mechanical construction such as flanged, screwed, or flared joints or compression fittings.

nonpositive displacement compressor: a compressor in which the increase in vapor pressure is attained without changing the internal volume of the compression chamber.

normative appendix: integral parts of the mandatory requirements of the standard, which, for reasons of convenience, are placed after all other normative elements.

occupancy: for class of occupancy see Section 4.

occupied space: that portion of the premises accessible to or occupied by people, excluding machinery rooms.

piping: the pipe or tube used to interconnect various parts of a refrigerating system. Piping includes pipe, flanges, bolting, gaskets, valves, fittings, pipe-supporting fixtures, structural attachments, and the pressure-containing parts of other components, such as expansion joints, strainers, filters, and devices that serve such purposes as mixing, separating, muffling, snubbing, distributing, metering, or controlling flow.

positive displacement compressor: a compressor in which the increase in pressure is attained by changing the internal volume of the compression chamber.

premises: a tract of land and the buildings thereon.

pressure-imposing element: any device or portion of the equipment used to increase refrigerant pressure.

pressure-limiting device: a pressure-responsive electronic or mechanical control designed to automatically stop the operation of the pressure-imposing element at a predetermined pressure.

pressure-relief device: a pressure-, not temperature-, actuated valve or rupture member designed to automatically relieve pressure in excess of its setting.

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pressure-relief valve: a pressure-actuated valve held closed by a spring or other means and designed to automatically relieve pressure in excess of its setting.

pressure vessel: any refrigerant-containing receptacle in a refrigerating system. This does not include evaporators where each separate evaporator section does not exceed 0.5 ft^3 (0.014 m^3) of refrigerant-containing volume regardless of the maximum inside dimension. This also does not include evaporator coils, compressors, condenser coils, controls, headers, pumps, and piping.

pumpdown charge: the quantity of refrigerant stored at some point in the refrigeration system for operational, service, or standby purposes.

readily accessible: capable of being reached safely and quickly for operation, repair, and inspection without requiring those to whom ready access is required to climb over or remove obstacles or to resort to the use of portable access equipment.

refrigerant: the fluid used for heat transfer in a refrigerating system; the refrigerant absorbs heat and transfers it at a higher temperature and a higher pressure, usually with a change of state.

refrigerating system: a combination of interconnected parts forming a closed circuit in which refrigerant is circulated for the purpose of extracting, then rejecting, heat. (See Section 5 for classification of refrigerating systems by type.)

refrigerating system, direct: (see 5.1.1).

refrigerating system, indirect: (see 5.1.2).

rupture member: a device that will rupture and release refrigerant to relieve pressure.

saturation pressure: the pressure at which vapor and liquid exist in equilibrium at a given temperature.

sealed absorption system: an absorption system in which all refrigerant-containing parts are made permanently tight by welding or brazing.

secondary coolant: any liquid used for the transmission of heat, without a change of state, and having no flash point or a flash point above 150°F (65.5°C) as determined by *ASTM D93.*[2]

self-contained system: a complete, factory-assembled and factory-tested system that is shipped in one or more sections and has no refrigerant-containing parts that are joined in the field by other than companion or block valves.

set pressure: the pressure at which a pressure-relief device or pressure control is set to operate.

shall (shall not): used when a provision is mandatory.

soldered joint: a gas-tight joint formed by joining metal parts with alloys that melt at temperatures not exceeding 800°F (426.5°C) and above 400°F (204.5°C).

specified: explicitly stated in detail. Specified limits or prescriptions are mandatory.

stop valve: a device used to shut off the flow of refrigerant.

tenant: a person or organization having the legal right to occupy a premises.

three-way valve: a service valve for dual pressure-relief devices that allows using one device while isolating the other from the system, maintaining one valve in operation at all times.

TLV-TWA (threshold limit value-time weighted average): the refrigerant concentration in air for a normal 8-hour workday and a 40-hour workweek to which repeated exposure, day after day, will not cause an adverse effect in most persons.[3]

ultimate strength: the stress at which rupture occurs.

unit system: (see *self-contained system*).

unprotected tubing: tubing that is unenclosed and therefore exposed to crushing, abrasion, puncture, or similar damage after installation.

zeotropic: refers to blends comprising multiple components of different volatility that, when used in refrigeration cycles, change volumetric composition and saturation temperatures as they evaporate (boil) or condense at constant pressure. The word is derived from the Greek words *zein* (to boil) and *tropos* (to change).

4. OCCUPANCY CLASSIFICATION

4.1 Locations of refrigerating systems are described by occupancy classifications that consider the ability of people to respond to potential exposure to refrigerant as follows:

4.1.1 *Institutional occupancy* is a premise or that portion of a premise from which, because they are disabled, debilitated, or confined, occupants cannot readily leave without the assistance of others. Institutional occupancies include, among others, hospitals, nursing homes, asylums, and spaces containing locked cells.

4.1.2 *Public assembly occupancy* is a premise or that portion of a premise where large numbers of people congregate and from which occupants cannot quickly vacate the space. Public assembly occupancies include, among others, auditoriums, ballrooms, classrooms, passenger depots, restaurants, and theaters.

4.1.3 *Residential occupancy* is a premise or that portion of a premise that provides the occupants with complete independent living facilities including permanent provisions for living, sleeping, eating, cooking, and sanitation. Residential occupancies include, among others, dormitories, hotels, multi-unit apartments, and private residences.

4.1.4 *Commercial occupancy* is a premise or that portion of a premise where people transact business, receive personal service, or purchase food and other goods. Commercial occupancies include, among others, office and professional buildings, markets (but not large mercantile occupancies), and work or storage areas that do not qualify as industrial occupancies.

4.1.5 *Large mercantile occupancy* is a premise or that portion of a premise where more than 100 persons congre-

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gate on levels above or below street level to purchase personal merchandise.

4.1.6 *Industrial occupancy* is a premise or that portion of a premise that is not open to the public, where access by authorized persons is controlled, and that is used to manufacture, process, or store goods such as chemicals, food, ice, meat, or petroleum.

4.1.7 *Mixed occupancy* occurs when two or more occupancies are located within the same building. When each occupancy is isolated from the rest of the building by tight walls, floors, and ceilings and by self-closing doors, the requirements for each occupancy shall apply to its portion of the building. When the various occupancies are not so isolated, the occupancy having the most stringent requirements shall be the governing occupancy.

4.2 Equipment, other than piping, located outside a building and within 20 ft (6.1 m) of any building opening shall be governed by the occupancy classification of the building.

Exception: Equipment located within 20 ft (6.1 m) of the building opening for the machinery room.

5. REFRIGERATING SYSTEM CLASSIFICATION

5.1 Refrigerating Systems. These systems are defined by the method employed for extracting or delivering heat as follows (see Figure 1):

5.1.1 *A direct system* is one in which the evaporator or condenser of the refrigerating system is in direct contact with the air or other substances to be cooled or heated.

5.1.2 *An indirect system* is one in which a secondary coolant cooled or heated by the refrigerating system is circulated to the air or other substance to be cooled or heated. Indirect systems are distinguished by the method of application given below.

5.1.2.1 *An indirect open spray system* is one in which a secondary coolant is in direct contact with the air or other substance to be cooled or heated.

5.1.2.2 *A double indirect open spray system* is one in which the secondary substance for an indirect open spray system (5.1.2.1) is heated or cooled by the secondary coolant circulated from a second enclosure.

5.1.2.3 *An indirect closed system* is one in which a secondary coolant passes through a closed circuit in the air or other substance to be cooled or heated.

5.1.2.4 *An indirect, vented closed system* is one in which a secondary coolant passes through a closed circuit in the air or other substance to be cooled or heated, except that the evaporator or condenser is placed in an open or appropriately vented tank.

5.2 Refrigeration System Classification. For the purpose of applying Tables 1 and 2, a refrigerating system shall be classified according to the degree of probability that a leakage of refrigerant will enter an occupancy-classified area as follows.

5.2.1 High-Probability System. A high-probability system is any system in which the basic design, or the location of components, is such that a leakage of refrigerant from a failed connection, seal, or component will enter the occupied space. Typical high-probability systems are (a) direct systems or (b) indirect open spray systems in which the refrigerant is capable of producing pressure greater than the secondary coolant.

Paragraph	Designation	Cooling or heating source	Air or substance to be cooled or heated
5.1.1	Direct system		
5.1.2.1	Indirect open spray system		
5.1.2.2	Double indirect open spray system	Vent	
5.1.2.3	Indirect closed system	Liquid expansion	
5.1.2.4	Indirect vented closed system		

Figure 1 *Refrigerating system designation.*

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Table 1
Refrigerant[a,f] and Amounts[b,e]

Refrigerant Number	Chemical Name	Chemical Formula	Quantity of Refrigerant per Occupied Space: Lb per 1000 ft^3 [a,c]	PPM by vol	g/m^3 [a,c]
Group A1					
R-11	Trichlorofluoromethane	CCl_3F	1.6	4,000	25
R-12	Dichlorodifluoromethane	CCl_2F_2	12	40,000	200
R-13	Chlorotrifluoromethane	$CClF_3$	18	67,000	290
R-13B1	Bromotrifluoromethane	$CBrF_3$	22	57,000	350
R-14	Tetrafluoromethane (Carbon tetrafluoride)	CF_4	15	67,000	240
R-22	Chlorodifluoromethane	$CHClF_2$	9.4	42,000	150
R-113	Trichlorotrifluoroethane	CCl_2FCClF_2	1.9	4,000	31
R-114	Dichlorotetrafluoroethane	$CClF_2CClF_2$	9.4	21,000	150
R-115	Chloropentafluoroethane	$CClF_2CF_3$	27	67,000	430
R-134a	1,1,1,2-Tetrafluoroethane	CH_2FCF_3	16	60,000	250
R-C318	Octafluorocyclobutane	C_4F_8	35	67,000	550
R-400	R-12 and R-114	$CCl_2F_2/C_2Cl_2F_4$	[d]	[d]	[d]
R-500	R-12/152a (73.8/26.2)	CCl_2F_2/CH_3CHF_2	12	47,000	200
R-502	R-22/115 (48.8/51.2)	$CHClF_2/CClF_2CF_3$	19	65,000	300
R-503	R-23/13 (40.1/59.9)	$CHF_3/CClF_3$	15	67,000	240
R-744	Carbon Dioxide	CO_2	5.7	50,000	91
Group A2					
R-142b	1-Chloro-1,1,-Difluoroethane	CH_3CClF_2	3.7	14,000	60
R-152a	1,1-Difluoroethane	CH_3CHF_2	1.2	7,000	20
Group A3					
R-170	Ethane	C_2H_6	0.50	6,400	8.0
R-290	Propane	C_3H_8	0.50	4,400	8.0
R-600	Butane	C_4H_{10}	0.51	3,400	8.2
R-600a	2-Methyl propane (Isobutane)	$CH(CH_3)_3$	0.51	3,400	8.2
R-1150	Ethene (Ethylene)	C_2H_4	0.38	5,200	6.0
R-1270	Propene (Propylene)	C_3H_6	0.37	3,400	5.9
Group B1					
R-123	2,2-Dichloro-1,1,1-Trifluoroethane	$CHCl_2CF_3$	0.40	1,000	6.3
R-764	Sulfur Dioxide	SO_2	0.016	100	0.26
Group B2					
R-40	Chloromethane (Methyl Chloride)	CH_3Cl	1.3	10,000	21
R-611	Methyl Formate	$HCOOCH_3$	0.78	5,000	12
R-717	Ammonia	NH_3	0.022	500	0.35

[a] The refrigerant safety groups in Table 1 are not part of ASHRAE Standard 15. The classifications shown are from ASHRAE Standard 34, which governs in the event of a difference.

[b] To be used only in conjunction with Section 7.

[c] To correct for height, H(ft), above sea level, multiply these values by $(1 - 2.42 \times 10^{-6}H)$. To correct for height, h(km), above sea level, multiply these values by $(1 - 7.94 \times 10^{-2}h)$.

[d] The quantity of each component shall comply with the limits set in Table 1 for the pure compound, and the total volume % of all components shall be calculated per Appendix A (not to exceed 67,000 ppm by volume for any refrigerant blend).

[e] The basis of the table quantities is a single event where a complete discharge of any refrigerant system into the occupied space occurs. The quantity of refrigerant is the most restrictive of a minimum oxygen concentration of 19.5% or as follows:

- Group A1— 80% of the cardiac sensitization level for R-11, R-12, R-13B1, R-22, R-113, R-114, R-134a, R-500, and R-502. 100% of the IDLH (21) for R-744. Others are limited by levels where oxygen depnvation begins to occur.
- Groups A2, A3— Approximately 20% of LFL.
- Group B1— 100% of IDLH for R-764, and 100% of the measure consistent with the IDLH for R-123.
- Groups B2, B3— 100% of IDLH or 20% of LFL, whichever is lower.

[f] It shall be the responsibility of the owner to establish the refrigerant group for refrigerants used that are not classified in ASHRAE Standard 34.

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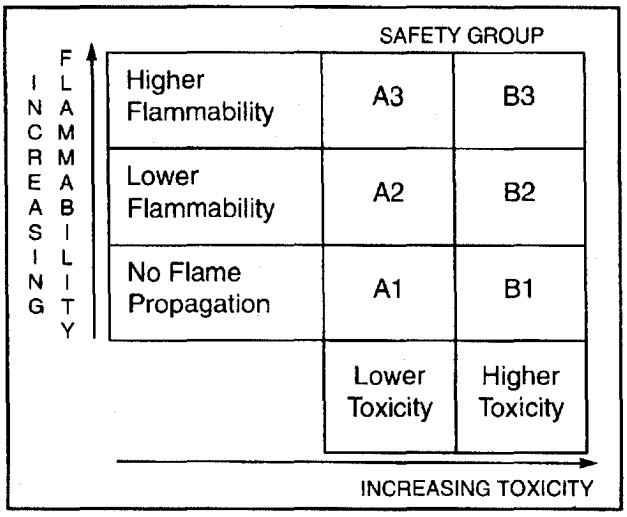
5.2.2 Low-Probability System. A low-probability system is any system in which the basic design, or location of the components, is such that leakage of refrigerant from a failed connection, seal, or component cannot enter the occupied space. Typical low-probability systems are (a) indirect closed systems or (b) double indirect systems and (c) indirect open spray systems if the following condition is met:

> In a low-probability indirect open spray system, the secondary coolant pressure shall remain greater than refrigerant pressure in all conditions of operation and standby. Operation conditions are defined in 9.2.2.1 and standby conditions are defined in 9.2.2.2.

5.3 Changing Refrigerant. A change in the type of refrigerant in a system shall not be made without the notification of the authority having jurisdiction, the user, and due observance of safety requirements. The refrigerant being considered shall be evaluated for suitability.

6. REFRIGERANT CLASSIFICATION

6.1 Refrigerants are classified by *ANSI/ASHRAE 34*[4] into safety groups illustrated in the following matrix:



6.2 Single-component refrigerants and azeotropic blends so classified are listed in *ANSI/ASHRAE 34-1992*[4] along with the criteria for classification. The safety group classifications shown in Table 1 of this standard originate in *ANSI/ASHRAE 34-1992*. Additional refrigerants are included in *ANSI/ASHRAE 34-1992*. As new data become available, refrigerant classifications are subject to change in *ANSI/ASHRAE 34-1992*.

6.3 Zeotropic blends are classified by worst-case composition of fractionation as follows:

For refrigerants that are capable of change in flammability or toxicity, such as by fractionation of zeotropes, a dual rating, separated by a solidus (/), shall be provided. The first rating shall be the classification of the refrigerants as formulated. The second rating shall be the classification of the worst-case composition of fractionation (see Appendix C for details).

7. RESTRICTIONS ON REFRIGERANT USE

7.1 System Selection. Refrigerating systems shall be applied in accordance with Table 2 and the requirements of 7.2, 7.3, and 7.4.

To use Table 2, determine the occupancy class in accordance with Section 4, safety refrigerant group per *ANSI/ASHRAE 34*[4] (a partial list is given in Table 1 for the convenience of the user), and type of system in accordance with Section 5, then locate the rules that apply. When more than one rule exists, each is a limitation on the other.

7.2 General Restrictions—Safeguards. Means shall be taken to adequately safeguard piping, controls, and other refrigerating equipment to minimize possible accidental damage or rupture by external sources.

7.3 General Restrictions—Nonindustrial Occupancy

7.3.1 Stairways and Exitways. Refrigerant piping shall not be installed in an enclosed public stairway, stair landing, or means of egress.

7.3.2 Corridors and Lobbies. Portions of a refrigerating system shall not interfere with free passage through public corridors, and refrigerating systems installed in a public corridor or lobby shall be limited to (a) unit systems containing not more than the quantities of Group A1 refrigerants specified in Table 1 or (b) sealed absorption systems as specified in Table 3.

7.3.3 Unventilated Spaces. When the refrigerant-containing parts of a system are located in one or more unventilated spaces, the volume of the smallest occupied space shall be used to determine the permissible quantity of refrigerant in the system. This does not apply to machinery rooms since they are always ventilated and are not considered occupied space. If the limitations of Table 1 are exceeded, a machinery room is required.

When a building consists of several stories of unpartitioned space, the permissible quantity of refrigerant in the system shall be based on the volume of the smallest occupied story.

7.3.4 Ventilated Spaces. When an evaporator or condenser is located in an air duct system, the volume of the smallest occupied space—or, in the case of an unpartitioned multi-story building, the volume of the smallest occupied story—served by the duct shall determine the permissible quantity of refrigerant in the system.

> ***Exception:*** When the air duct system serves several enclosed spaces, the permissible quantity of refrigerant in the system shall not exceed the amount determined by using the total volume of those spaces in which the airflow cannot be reduced to less than one-quarter of its maximum when the fan is operating.

7.3.5 Plenums. The space above a suspended ceiling shall not be included in calculating the permissible quantity of refrigerant in the system unless such space is continuous and is part of the air return system.

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Table 2 System Application Requirements[a]

Refrigerant Group	System Probability[b]	Occupancy: Institutional	Occupancy: Public Assembly, Residential, Commercial & Large Mercantile	Occupancy: Industrial[c]
A1	High	2	1	3
	Low	4	4	4
A2	High	5	5	3
	Low	7	7	7
A3	High	9	9	3
	Low	9	9	7
B1	High	2,6	1,6	3
	Low	4	4	4
B2	High	5,6	5,6	3
	Low	7	7	7
B3	High	9	9	3
	Low	9	9	7

[a]Numbers in the table under "Occupancy" refer to rules in Section 7.4.
[b]See Section 5.2 for determining the system probability.
[c]Rule 8 is referenced when Rule 3 is applied.

Table 3[a] Maximum Permissible Quantities of Refrigerants for Use with Rule 5 (See 7.4)

Type of Refrigeration System	Maximum Pounds (kg) for Various Occupancies: Institutional	Pub/Large Mercantile	Residential	Commercial
Sealed Absorption System				
In public hallways or lobbies	0(0)	0(0)	3.3(1.5)	3.3(1.5)
In adjacent outdoor locations	0(0)	0(0)	22(10)	22(10)
In other than public hallways or lobbies	0(0)	6.6(3)	6.6(3)	22(10)
Unit Systems				
In other than public hallways or lobbies	0(0)	0(0)	6.6(3)	22(10)

[a]Table 3 referenced in Table 2, Rule 5.

7.4 System Application Requirements

7.4.1 Equipment Applied in a High-Probability System. In addition to the provisions of 2.5, listed equipment with refrigerant charge not exceeding 6.6 lb (3 kg) shall be deemed to meet the system application requirements when the equipment is installed in accordance with its listing and manufacturer's installation instructions.

7.4.2 General System Application Requirements. Except as permitted in 7.4.1, the following rules for system application requirements are applied as specified in Table 2, based on refrigerant group,[4] system probability, and occupancy. These rules do not stand alone.

Blends that are capable of fractionating to change the flammability or toxicity (see 6.2) are treated according to their worst-case classification. For example, an A1/A2 blend follows the rules for A2 refrigerants. The amount of blend allowed corresponds to the limit on the quantity of A2 refrigerant in the blend. The total amount of the blend is limited as in footnote d of Table 1.

Rules:

1. The quantity of refrigerant in each system shall be limited as listed in Table 1. The quantity of refrigerant per occupied space shall be the maximum amount of refrigerant that will leak into the occupied space at any one time, based on a leak from any single independent refrigeration circuit.
2. The quantity of refrigerant in each system is limited to 50% of the amount listed in Table 1.

   Exception: Rule 1 applies in kitchens, laboratories, and mortuaries. If any portion of a refrigerant system containing more than one pound of refrigerant (except R-744) is in a room with a flame-sustaining device, this device shall be provided with a hood to exhaust combustion products to the open air. Otherwise Rules 5 and 6 shall be followed.
3. For refrigerating systems of 100 hp (74.6 kW) or less, when the quantity of refrigerant in each system exceeds Table 1 quantities, the rules for commercial occupancy shall apply unless the following occurs:

   (a) occupancies containing machinery are separated from other occupancies by tight construction and with tight-fitting doors;

   (b) access by authorized personnel is controlled;

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(c) personnel density and means of egress are in compliance with local building codes;

(d) detectors (refrigerant, oxygen, etc.) are located in areas where refrigerant vapor from a leak will be concentrated so as to provide warning at a concentration not exceeding the refrigerant(s) TLV-TWA (detectors are not required for ammonia due to its self-alarming character);

(e) when the quantity of refrigerant, except refrigerants in Groups A1 and B1, exceeds Table 1 quantities, no flame-producing device or hot surface above 800°F (426.7°C) shall be permitted; and

(f) when the quantity of refrigerant, except Groups A1 and B1 and ammonia, exceeds Table 1 quantities, the area shall be classified as a hazardous location and all electrical equipment shall conform to the requirements of Class 1, Division 2, of the National Electrical Code.[9]

For refrigerating systems of greater than 100 hp (74.6 kW), the refrigerated work area shall comply with items (a) through (f) and the separate room housing compressors and related equipment shall comply with Rule 8.

4. When the quantity of refrigerant in any system exceeds Table 1 amounts, all refrigerant-containing parts, except piping and those parts outside the building, shall be installed in a machinery room constructed in accordance with the provisions of 8.13.
5. Refrigerant quantities and types of systems shall be limited as shown in Table 3.
6. Applications involving air conditioning for human comfort are not allowed.
7. When the quantity of refrigerant in any system exceeds Table 1 amounts, all refrigerant-containing parts, except piping and those parts outside the building, shall be installed in a machinery room constructed in accordance with the provisions of 8.14 with limitations on refrigerant quantities as follows:

   550 lb (250 kg)—Institutional
   No limit except Rule 8—Public Assembly and Large Mercantile
   No limit except Rule 8—Residential
   No limit except Rule 8—Commercial
   No limit except Rule 8—Industrial

   Otherwise, Rule 5 limits the amount of Group A2, A3, B2, or B3 refrigerant in the system.
8. When the quantity of refrigerant in any system exceeds Table 1 amounts, all refrigerant-containing parts except piping, lowside components, condensers, and parts outside the building shall be installed in a machinery room constructed in accordance with the provisions of 8.13. In addition, refrigerants of Groups A2, A3, B2, and B3 shall meet the following requirements:

   (a) The special machinery room requirements of 8.14 shall apply.

   (b) Except for ammonia systems, amounts of refrigerant exceeding 1100 lb (500 kg) shall be approved by the authority having jurisdiction.

9. Use of these refrigerants is prohibited except in laboratories in commercial occupancies. Only unit systems containing not more than 6.6 lb (3 kg) of Group A3 or B3 refrigerant shall be used unless the laboratory is occupied by less than one person per 100 ft^2 (9.3 m^2) of floor area, in which case the requirements of industrial occupancies shall apply. Note that 7.4.1 permits a refrigerant charge of 6.6 lb (3 kg) or less (any refrigerant) of any system meeting the requirements of this rule.

8. INSTALLATION RESTRICTIONS

8.1 Foundations. Foundations and supports for condensing units or compressor units shall be of noncombustible construction and capable of supporting loads imposed by such units. Isolation materials such as rubber are permissible between the foundation and condensing or compressor units.

8.2 Guards. Moving machinery shall be guarded in accordance with approved safety standards.[6,7]

8.3 Safe Access. Access, including ladders, platforms, and clear space for inspection and servicing of condensing units, compressors, condensers, and other machinery, shall be provided in accordance with the requirements of the authority having jurisdiction.

8.4 Enclosures. Condensing units or compressor units with enclosures shall be readily accessible for servicing and inspection.

8.5 Water Connections. Water supply and discharge connections shall be made in accordance with the requirements of the authority having jurisdiction.

8.6 Illumination. Illumination adequate for inspection and servicing of condensing units or compressor units shall be provided.[8]

8.7 Electrical Safety. Electrical equipment and wiring shall be installed in accordance with the National Electrical Code[9] and the requirements of the authority having jurisdiction.

8.8 Gas Fuel Equipment. Gas fuel devices and equipment used with refrigerating systems shall be installed in accordance with approved safety standards[10,11] and the requirements of the authority having jurisdiction.

8.9 Air Duct Installation. Air duct systems of air-conditioning equipment for human comfort using mechanical refrigeration shall be installed in accordance with approved safety standards,[12,13] the requirements of the authority having jurisdiction, and the requirements of 8.13.7.

8.10 Refrigerant Parts in Air Duct. Joints and all refrigerant-containing parts of a refrigerating system located in an air duct carrying conditioned air to and from an occupied space shall be constructed to withstand a temperature of 700°F (371.1°C) without leakage into the airstream.

8.11 Refrigerant Pipe Joint Inspection. Refrigerant pipe joints erected on the premises shall be exposed to view for visual inspection prior to being covered or enclosed.

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8.12 Location of Refrigerant Piping

8.12.1 Refrigerant piping crossing an open space that affords passageway in any building shall be not less than 7.25 ft (2.2 m) above the floor unless the piping is located against the ceiling of such space and is permitted by the authority having jurisdiction.

8.12.2 Passages shall not be obstructed by refrigerant piping. Refrigerant piping shall not be placed in any elevator, dumbwaiter, or other shaft containing a moving object or in any shaft that has openings to living quarters or to means of egress. Refrigerant piping shall not be installed in an enclosed public stairway, stair landing, or means of egress.

8.12.3 Refrigerant piping shall not penetrate floors, ceilings, or roofs.

Exceptions:

(a) Penetrations connecting the basement and the first floor.

(b) Penetrations connecting the top floor and a machinery penthouse or roof installation.

(c) Penetrations connecting adjacent floors served by the refrigeration system.

(d) In other than industrial occupancies, penetrations that connect separate pieces of equipment that are (1) enclosed by an approved gas-tight, fire-resistive duct or shaft with openings to those floors served by the refrigeration system or (2) located on the exterior wall of a building when vented to the outside or to the space served by the system and not used as an air shaft, closed court, or similar space.

(e) Piping of a direct system where the refrigerant quantity limited by Section 7 is not required to be enclosed when it connects stories served by that system.

8.12.4 Refrigerant piping installed in concrete floors shall be encased in pipe duct. Refrigerant piping shall be properly isolated and supported to prevent damaging vibration, stress, or corrosion.

8.13 Refrigerating Machinery Room, General Requirements. When a refrigerating system is located indoors and a machinery room is required by 7.4, the machinery room shall be in accordance with the following provisions.

8.13.1 Machinery rooms are not prohibited from housing other mechanical equipment unless specifically prohibited elsewhere in this standard. A machinery room shall be so dimensioned that parts are accessible with space for service, maintenance, and operations. There shall be clear head room of not less than 7.25 ft (2.2 m) below equipment situated over passageways.

8.13.2 Each refrigerating machinery room shall have a tight-fitting door or doors opening outward, self-closing if they open into the building, and adequate in number to ensure freedom for persons to escape in an emergency. With the exception of access doors and panels in air ducts and air-handling units conforming to 8.13.7, there shall be no openings that will permit passage of escaping refrigerant to other parts of the building.

Each machinery room shall contain a detector, located in an area where refrigerant from a leak will concentrate, which shall actuate an alarm and mechanical ventilation in accordance with 8.13.4 at a value not greater than the corresponding TLV-TWA (or toxicity measure consistent therewith).

Exception: For ammonia refer to 8.14(g).

8.13.3 Machinery rooms shall be vented to the outdoors, utilizing mechanical ventilation in accordance with 8.13.4 and 8.13.5.

8.13.4 Mechanical ventilation referred to in 8.13.3 shall be by one or more power-driven fans capable of exhausting air from the machinery room at least in the amount given in the formula in 8.13.5. To obtain a reduced airflow for normal ventilation, multiple fans or multispeed fans shall be used. Provision shall be made for inlet air to replace that being exhausted. Openings for inlet air shall be positioned to avoid recirculation. Air supply and exhaust ducts to the machinery room shall serve no other area. The discharge of the air shall be to the outdoors in such a manner as not to cause a nuisance or danger.

8.13.5 The mechanical ventilation required to exhaust an accumulation of refrigerant due to leaks or a rupture of the system shall be capable of removing air from the machinery room in not less than the following quantity:

$$Q = 100 \times G^{0.5} \; (Q = 70 \times G^{0.5})$$

where

Q = the airflow in cubic feet per minute (liters per second),

G = the mass of refrigerant in pounds (kilograms) in the largest system, any part of which is located in the machinery room.

A part of the refrigerating machinery room mechanical ventilation shall be

(a) operated, when occupied, to supply at least 0.5 cfm per square foot (2.54 L/s per square meter) of machinery room area or 20 cfm (9.44 L/s) per person and

(b) operable, if necessary for operator comfort, at a volume required to maintain a maximum temperature rise of 18°F (10°C) based on all of the heat-producing machinery in the room.

When a refrigerating system is located outdoors more than 20 ft (6.1 m) from building openings and is enclosed by a penthouse, lean-to, or other open structure, natural or mechanical ventilation shall be provided. The requirements for such natural ventilation are as follows:

(c) The free-aperture cross section for the ventilation of a machinery room shall be at least

$$F = G^{0.5} \; (F = 0.138 G^{0.5})$$

where

F = the free opening area in square feet (square meters),

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G = the mass of refrigerant in pounds (kilograms) in the largest system, any part of which is located in the machinery room.

(d) Locations of the gravity ventilation openings shall be based on the relative density of the refrigerant to air.

8.13.6 No open flames that use combustion air from the machinery room shall be installed where any refrigerant is used. The use of matches, lighters, halide leak detectors, and similar devices shall not be considered a violation of 8.13.6. Combustion equipment shall not be installed in the same machinery room with refrigerant-containing equipment except under one of the following conditions:

(a) combustion air is ducted from outside the machinery room and sealed in such a manner as to prevent any refrigerant leakage from entering the combustion chamber, or

(b) a refrigerant vapor detector is employed to automatically shut down the combustion process in the event of refrigerant leakage.

Exceptions:

(1) Machinery rooms where only carbon dioxide (R-744) is the refrigerant.

(2) Machinery rooms where only ammonia (R-717) is the refrigerant and internal combustion engines are used as the prime mover for the compressors.

8.13.7 There shall be no airflow to or from an occupied space through a machinery room unless the air is ducted and sealed in such a manner as to prevent any refrigerant leakage from entering the airstream. Access doors and panels in ductwork and air-handling units shall be gasketed and tight fitting.

8.14 Machinery Room, Special Requirements. In cases specified in the rules of 7.4.2, a refrigerating machinery room shall meet the following special requirements in addition to those in 8.13:

(a) There shall be no flame-producing device or continuously operating hot surface over 800°F (427°C) permanently installed in the room.

(b) Doors communicating with the building shall be approved, self-closing, tight-fitting fire doors.

(c) Walls, floor, and ceiling shall be tight and of noncombustible construction. Walls, floor, and ceiling separating the refrigerating machinery room from other occupied spaces shall be of at least one-hour fire-resistive construction.

(d) The refrigerating machinery room shall have a door that opens directly to the outside air or through a vestibule equipped with self-closing, tight-fitting doors.

(e) Exterior openings, if present, shall not be under any fire escape or any open stairway.

(f) All pipes piercing the interior walls, ceiling, or floor of such rooms shall be tightly sealed to the walls, ceiling, or floor through which they pass.

(g) When refrigerants of Groups A2, A3, B2, and B3 are used, the machinery room shall conform to Class 1, Division 2, of the National Electrical Code.[9] When refrigerant Groups A1 and B1 are used, the machinery room is not required to meet Class 1, Division 2, of the National Electrical Code

Exception: When ammonia is used, the requirements of Class 1, Division 2, of the National Electrical Code shall not apply providing the requirements of 8.14(h) are met.

(h) When ammonia is used, the machinery room is not required to meet Class 1, Division 2, of the National Electrical Code providing (1) the mechanical ventilation system in the machinery room is run continuously and failure of the mechanical ventilation system actuates an alarm or (2) the machinery room is equipped with a vapor detector that will automatically start the mechanical ventilation system and actuate an alarm at a detection level not to exceed 1,000 ppm.

(i) Remote control of the mechanical equipment in the refrigerating machinery room shall be provided immediately outside the machinery room door solely for the purpose of shutting down the equipment in an emergency. Ventilation fans shall be on a separate electrical circuit and have a control switch located immediately outside the machinery room door.

8.15 Manual Emergency Discharge of Ammonia Refrigerant. When required by the authority having jurisdiction, manual emergency discharge or diffusion arrangements for ammonia refrigerants shall be provided. Appendix B contains information on emergency discharge of ammonia refrigerants.

8.16 Purge Discharge. The discharge of purge systems shall be governed by the same rules as pressure-relief devices and fusible plugs (see 9.7.8) and shall be piped in conjunction with these devices.

9. DESIGN AND CONSTRUCTION OF EQUIPMENT AND SYSTEMS

9.1 Materials

9.1.1 Materials used in the construction and installation of refrigerating systems shall be suitable for conveying the refrigerant used. Materials shall not be used that will deteriorate because of the refrigerant, the lubricant, or their combination in the presence of air or moisture to a degree that poses a safety hazard.

9.1.2 Aluminum, zinc, magnesium, or their alloys shall not be used in contact with methyl chloride. Magnesium alloys shall not be used in contact with any halogenated refrigerants.

9.1.3 Copper and its alloys shall not be used in contact with ammonia except as a component of bronze alloys for bearings or other non-refrigerant-containing uses.

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9.1.4 Aluminum and its alloys are suitable for use in ammonia systems.

9.2 System Design Pressure

9.2.1 Design pressures shall not be less than pressure arising under maximum operating, standby, or shipping conditions. When selecting the design pressure, allowance shall be provided for setting pressure-limiting devices and pressure-relief devices to avoid nuisance shutdowns and loss of refrigerant. The *ASME Boiler and Pressure Vessel Code*,[14] Section VIII, Division I, Appendix M, contains information on the appropriate allowances for design pressure.

Design pressure shall not be less than 15 psig (103.4 kPa gage) and, except as noted in 9.2.2, 9.2.3, 9.2.4, and 9.2.5, shall not be less than the saturation pressure (gage) corresponding to the following temperatures:

(a) Lowsides of all systems: 80°F (26.7°C).

(b) Highsides of all water-cooled or evaporatively cooled systems: 30°F (16.7°C) higher than the summer 1% wet-bulb for the location as applicable or 15°F (8.3°C) higher than the highest design leaving condensing water temperature for which the equipment is designed or 104°F (40°C), whichever is greatest.

(c) Highsides of all air-cooled systems: 30°F (16.7°C) higher than the highest summer 1% design dry-bulb for the location but not lower than 122°F (50°C).

Note: See references 23 and 24 for sources of information relating to summer 1% wet-bulb and summer 1% dry-bulb data for a specific location.

9.2.1.1 The design pressure selected shall exceed maximum pressures attained under any anticipated normal operating conditions, including conditions created by expected fouling of heat exchange surfaces.

9.2.1.2 Standby conditions are intended to include normal conditions that are capable of being attained when the system is not in operation (e.g., maintenance, shutdown, power failure). Selection of the design pressure for lowside components shall also consider pressure developed in the lowside of the system from equalization, or heating due to changes in ambient temperature, after the system has stopped.

9.2.1.3 The design pressure for both lowside and highside components that are shipped as part of a gas- or refrigerant-charged system shall be selected with consideration of internal pressures arising from exposure to maximum temperatures anticipated during the course of shipment.

9.2.2 The design pressure for either the highside or lowside need not exceed the critical pressure of the refrigerant unless such pressures are anticipated during operating, standby, or shipping conditions.

9.2.3 When part of a limited charge system is protected by a pressure-relief device, the design pressure of the part need not exceed the setting of the pressure-relief device.

9.2.4 When a compressor is used as a booster and discharges into the suction side of another compressor, the booster compressor shall be considered a part of the lowside.

9.2.5 Components connected to pressure vessels and subject to the same pressure as the pressure vessel shall have a design pressure no less than the pressure vessel.

9.3 Refrigerant-Containing Pressure Vessels

9.3.1 Inside Dimensions 6 Inches or Less. These vessels have an inside diameter, width, height, or cross-sectional diagonal not exceeding 6 in. (152 mm) with no limitation on length of vessel.

9.3.1.1 Pressure vessels having inside dimensions of 6 in. (152 mm) or less shall be

(a) listed either individually or as part of an assembly by an approved, nationally recognized testing laboratory, or

(b) shall be marked directly on the vessel or on a nameplate attached to the vessel with a "U" or "UM" symbol signifying compliance with Section VIII of the *ASME Boiler and Pressure Vessel Code*,[14] or

(c) when requested by the authority having jurisdiction, the manufacturer shall provide documentation to confirm that the vessel meets the design, fabrication, and testing requirements of Section VIII of the *ASME Boiler and Pressure Vessel Code*.[14]

Exception: Vessels having an internal or external design pressure of 15 psig (103.4 kPa gage) or less.

Pressure vessels having inside dimensions of 6 in. (152 mm) or less shall be protected by either a pressure-relief device or a fusible plug.

9.3.1.2 If a pressure-relief device is used to protect a pressure vessel having an inside dimension of 6 in. (152 mm) or less, the ultimate strength of the pressure vessel so protected shall be sufficient to withstand a pressure at least 3.0 times the design pressure.

9.3.1.3 If a fusible plug is used to protect a pressure vessel having an inside diameter of 6 in. (152 mm) or less, the ultimate strength of the pressure vessel so protected shall be sufficient to withstand a pressure 2.5 times the saturation pressure of the refrigerant used at the temperature stamped on the fusible plug or 2.5 times the critical pressure of the refrigerant used, whichever is less.

9.3.2 Inside Dimensions Greater than 6 Inches. Pressure vessels having an inside diameter exceeding 6 in. (152 mm) and having an internal or external design pressure greater than 15 psig (103.4 kPa gage) shall be directly marked, or marked on a nameplate, with a "U" or "UM" symbol signifying compliance with the rules of Section VIII of the *ASME Boiler and Pressure Vessel Code*.[14]

9.3.3 Pressure Vessels for 15 psig or Less. Pressure vessels having an internal or external design pressure of 15 psig (103.4 kPa gage) or less shall have an ultimate strength to withstand at least 3.0 times the design pressure and shall be tested with a pneumatic test pressure no less than 1.25 times the design pressure or a hydrostatic test pressure no less than 1.50 times the design pressure.

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9.4 Pressure-Relief Protection

9.4.1 Refrigerating systems shall be protected by a pressure-relief device or other approved means to safely relieve pressure due to fire or other abnormal conditions.

9.4.2 Pressure vessels shall be protected in accordance with 9.7. Pressure-relief devices are acceptable if they bear either a nameplate or are directly marked with a "UV" or "VR" symbol signifying compliance with Section VIII of the *ASME Boiler and Pressure Vessel Code.*[14]

9.4.3 A pressure-relief device to relieve hydrostatic pressure to another part of the system shall be used on the portion of liquid-containing parts of the system that is capable of being isolated from the system during operation or service and that will be subjected to overpressure from hydrostatic expansion of the contained liquid due to temperature rise.

9.4.4 Evaporators located downstream, or upstream within 18 in. (460 mm), of a heating coil shall be fitted with a pressure-relief device discharging outside the building in accordance with the requirements of 9.7.8.

Exceptions:

(1) Relief valves shall not be required on heating coils that are designed to produce a temperature that will result in the saturation pressure of the refrigerant being less than the design pressure.

(2) A relief valve shall not be required on self-contained or unit systems if the volume of the lowside of the system, which is shut off by valves, is greater than the specific volume of the refrigerant at critical conditions of temperature and pressure, as determined by the following formula:

$$V_1 / [W_1 - (V_2 - V_1) / V_{gt}] \text{ shall be greater than } V_{gc}$$

where

V_1 = lowside volume, ft^3 (m^3);
V_2 = total volume of system, ft^3 (m^3);
W_1 = total weight of refrigerant in system, lb (kg);
V_{gt} = specific volume of refrigerant vapor at 110°F (43.5°C), ft^3/lb (m^3/kg);
V_{gc} = specific volume at critical temperature and pressure, ft^3/lb (m^3/kg).

9.4.5 Pressure-relief devices shall be direct-pressure actuated or pilot-operated. Pilot-operated pressure-relief valves shall be self-actuated, and the main valve shall open automatically at the set pressure and, if some essential part of the pilot fails, shall discharge its full rated capacity.

9.4.6 Stop valves shall not be located between a pressure-relief device and parts of the system protected thereby. A three-way valve, used in conjunction with the dual relief valve requirements of 9.7.2.3, is not considered a stop valve.

9.4.7 When relief valves are connected to discharge to a common discharge header as described in 9.7.8.4, a full area stop valve is not prohibited from being installed in the discharge pipe between the relief valve and the common header. When such a stop valve is installed, a locking device shall be installed to ensure that the stop valve is locked in the open position. This discharge stop valve shall not be shut unless one of the following conditions exists:

(a) parallel relief valves are installed and the second relief valve is protecting the system or vessels, or

(b) the system or vessels have been depressurized and are vented to the atmosphere.

9.4.8 Pressure-relief devices shall be connected directly to the pressure vessel or other parts of the system protected thereby. These devices shall be connected above the liquid refrigerant level and installed so that they are accessible for inspection and repair and so that they cannot be readily rendered inoperative.

Exception: When fusible plugs are used on the highside, they shall be located either above or below the liquid refrigerant level.

9.4.9 The seats and discs of pressure-relief devices shall be constructed of suitable material to resist refrigerant corrosion or other chemical action caused by the refrigerant. Seats or discs of cast iron shall not be used. Seats and discs shall be limited in distortion, by pressure or other cause, to a set pressure change of not more than 5% in a span of five years.

9.5 Setting of Pressure-Relief Devices

9.5.1 Pressure-Relief Valve Setting. Pressure-relief valves shall start to function at a pressure not to exceed the design pressure of the parts of the system protected.

9.5.2 Rupture Member Setting. Rupture members used in lieu of, or in series with, a relief valve shall have a nominal rated rupture pressure not to exceed the design pressure of the parts of the system protected. The conditions of application shall conform to the requirements of paragraph UG-127 of Section VIII, Division 1, of the *ASME Boiler and Pressure Vessel Code.*[14] The size of rupture members installed ahead of relief valves shall not be less than the relief valve inlet.

9.6 Marking of Relief Devices and Fusible Plugs

9.6.1 Pressure-relief valves for refrigerant-containing components shall be set and sealed by the manufacturer or an assembler as defined in Section VIII, Division 1, of the *ASME Boiler and Pressure Vessel Code.*[14] Each pressure-relief valve shall be marked by the manufacturer or assembler with the data required in Section VIII, Division 1, of the *ASME Boiler and Pressure Vessel Code.*[14]

Exception: Relief valves for systems with design pressures of 15 psig (103.4 kPa gage) or less shall be marked by the manufacturer with the pressure-setting capacity.

9.6.2 Each rupture member for refrigerant pressure vessels shall be marked with the data required in paragraph UG-129(e) of Section VIII, Division 1, of the *ASME Boiler and Pressure Vessel Code.*[14]

9.6.3 Fusible plugs shall be marked with the melting temperatures in Fahrenheit or Celsius.

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9.7 Pressure Vessel Protection

9.7.1 Pressure vessels shall be provided with overpressure protection in accordance with rules in Section VIII, Division 1, of the *ASME Boiler and Pressure Vessel Code*.[14]

9.7.2 Pressure vessels containing liquid refrigerant and that are capable of being isolated by stop valves from other parts of a refrigerating system shall be provided with overpressure protection. Pressure-relief devices or fusible plugs shall be sized in accordance with 9.7.5.

9.7.2.1 Pressure vessels with an internal gross volume of 3 ft^3 (0.085 m^3) or less shall use one or more pressure-relief devices or a fusible plug.

9.7.2.2 Pressure vessels of more than 3 ft^3 (0.085 m^3) but less than 10 ft^3 (0.285 m^3) internal gross volume shall use one or more pressure-relief devices. Fusible plugs shall not be used.

9.7.2.3 Pressure vessels of 10 ft^3 (0.285 m^3) or more internal gross volume shall use a single rupture member or dual pressure-relief valves when discharging to the atmosphere. Dual pressure-relief valves shall be installed with a three-way valve to allow testing or repair.

9.7.2.4 One or more relief valves shall be used on pressure vessels of 10 ft^3 (0.285 m^3) or more internal gross volume if:

(a) the relief valves are located on the lowside of the system,

(b) shut-off valves are installed to isolate the vessels from the rest of the refrigerating system, and

(c) the system is designed to allow pumpdown of the refrigerant charge of the pressure vessel.

9.7.3 For pressure-relief valves discharging into the lowside of the system, a single relief valve (not rupture member) of the required relieving capacity shall not be used on vessels of 10 ft^3 (0.283 m^3) or more internal gross volume except under the conditions permitted in 9.7.8.1.

9.7.4 Large vessels containing liquid refrigerant shall not be prohibited from using two or more pressure-relief devices or dual pressure-relief devices in parallel to obtain the required capacity.

9.7.5 The minimum required discharge capacity of the pressure-relief device or fusible plug for each pressure vessel shall be determined by the following:

$$C = fDL$$

where

C = minimum required discharge capacity of the relief device in pounds of air per minute (kg/s),

D = outside diameter of vessel in feet (m),

L = length of vessel in feet (m), and

f = factor dependent upon type of refrigerant.

Notes:

(1) When combustible materials are used within 20 ft (6.1 m) of a pressure vessel, multiply the value of f by 2.5.

(2) The formula is based on fire conditions. Other heat sources shall be calculated separately.

Refrigerant	Value of f
When used on the lowside of a limited-charge cascade system:	
R-170, R-744, R-1150	1.0 (0.082)
R-13, R-13B1, R-503	2.0 (0.163)
R-14	2.5 (0.203)
Other applications:	
R-717	0.5 (0.041)
R-11, R-40, R-113, R-123, R-142b, R-152a, R-290, R-600, R-600a, R-611, R-764	1.0 (0.082)
R-12, R-22, R-114, R-134a, R-C318, R-500, R-1270	1.6 (0.131)
R-115, R-502	2.5 (0.203)

When one pressure-relief device or fusible plug is used to protect more than one pressure vessel, the required capacity shall be the sum of the capacities required for each pressure vessel.

9.7.6 The rated discharge capacity of a pressure-relief device expressed in pounds of air per minute (kilograms of air per second) shall be determined in accordance with paragraph UG-131, Section VIII, Division 1, of the *ASME Boiler and Pressure Vessel Code*.[14] All pipe and fittings between the pressure-relief valve and the parts of the system it protects shall have at least the area of the pressure-relief valve inlet area.

9.7.7 The rated discharge capacity of a rupture member or fusible plug discharging to the atmosphere under critical flow conditions in pounds of air per minute (kg/s) shall be determined by the following formulas:

$$C = 0.64 P_1 d^2 \qquad (C = 1.09 \times 10^{-6} P_1 d^2),$$

$$d = 1.25 (C/P_1)^{0.5} \qquad (d = 958.7 (C/P_1)^{0.5}),$$

where

C = rated discharge capacity in pounds of air per minute (kg/s) and

d = smallest of the internal diameter of the inlet pipe, retaining flanges, fusible plug, and rupture member in inches (mm)

where
for rupture members,

P_1 = (rated pressure psig [kPa gage] × 1.10) + 14.7 (101.33);

for fusible plugs, P_1 = absolute saturation pressure corresponding to the stamped temperature melting point of the fusible plug or the critical pressure of the refrigerant used, whichever is smaller, psia (kPa).

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9.7.8 Pressure-relief devices and fusible plugs on any system containing a Group A3 or B3 refrigerant; on any system containing more than 6.6 lb (3 kg) of a Group A2, B1, or B2 refrigerant; and on any system containing more than 110 lb (50 kg) of a Group A1 refrigerant shall discharge to the atmosphere at a location not less than 15 ft (4.57 m) above the adjoining ground level and not less than 20 ft (6.1 m) from any window, ventilation opening, or exit in any building. The discharge shall be terminated in a manner that will prevent the discharged refrigerant from being sprayed directly on personnel in the vicinity and foreign material or debris from entering the discharge piping. Discharge piping connected to the discharge side of a fusible plug or rupture member shall have provisions to prevent plugging the pipe in the event the fusible plug or rupture member functions.

9.7.8.1 Pressure-relief devices required in 9.4 and 9.7 shall not discharge into the lowside of the system unless the pressure-relief device is a type not affected by back pressure and the lowside is equipped with pressure-relief devices capable of relieving any increased refrigerant quantity. Such a lowside pressure-relief device shall be set in accordance with 9.5.1 and vented to the outside of the building in accordance with 9.7.8.

Exception: Hydrostatic relief valves.

9.7.8.2 Ammonia Discharge. Ammonia from pressure-relief valves shall be discharged into one or more of the following:

(a) The atmosphere, per 9.7.8.

(b) A tank containing one gallon of water for each pound of ammonia (8 kg of water for each kilogram of ammonia) that will be released in one hour from the largest relief device connected to the discharge pipe. The water shall be prevented from freezing. The discharge pipe from the pressure-relief device shall distribute ammonia in the bottom of the tank but no lower than 33 ft (10 m) below the maximum liquid level. The tank shall contain the volume of water and ammonia without overflowing.

(c) Other treatment systems that meet the requirements of the authority having jurisdiction.

9.7.8.3 Optional Sulfur Dioxide Discharge. When sulfur dioxide is used, the discharge shall be into a tank of absorptive solution that shall be used for no other purpose except sulfur dioxide absorption. The absorptive solution shall be one gallon of standard dichromate solution (2.5 lb of sodium dichromate per gallon of water [300 grams of sodium dichromate per liter of water]) for each pound of sulfur dioxide in the system (8.3 liters of standard dichromate solution for each kilogram of sulfur dioxide in the system). Solutions made with caustic soda or soda ash shall not be used in place of sodium dichromate unless the quantity and strength have the equivalent sulfur-dioxide-absorbing power. The tank shall be constructed of not less than 1/8 in. (3.2 mm) or No. 11 U.S. gage iron or steel. The tank shall have a hinged cover or, if of the enclosed type, shall have a vent hole at the top. All pipe connections shall be through the top of the tank only. The discharge pipe from the pressure-relief valve shall discharge the sulfur dioxide in the center of the tank near the bottom.

9.7.8.4 The size of the discharge pipe from a pressure-relief device or fusible plug shall not be less than the outlet size of the pressure-relief device or fusible plug. Where outlets of two or more relief devices or fusible plugs are connected to a common line or header, the effect of back pressure that will be developed when more than one relief device or fusible plug operates shall be considered. The sizing of the common discharge header downstream from each of the two or more relief devices or fusible plugs that are expected to operate simultaneously shall be based on the sum of their outlet areas with due allowance for the pressure drop in all downstream sections.

9.7.8.5 The maximum length of the discharge piping installed on the outlet of a pressure-relief device or fusible plug shall be determined as follows:

$$L = 9P^2d^5/16C_r^2 \qquad (L = 1.95 \times 10^{-14}P^2d^5/C_r^2)$$

where

C_r = rated discharge capacity as stamped on the device by the manufacturer in pounds of air per minute (kg/s),
d = internal diameter of pipe in inches (mm),
L = length of discharge pipe in feet (m).

For relief valves and rupture disks: P = (rated pressure, psig [kPa gage] × 1.10) + 14.7 (101.33). For fusible plugs: P = pressure, P_1, as defined in 9.7.7.

See Table 4 for the results of computations using the above formula.

9.8 Positive Displacement Compressor Protection. When equipped with a stop valve in the discharge connection, every positive displacement compressor shall be equipped with a pressure-relief device of adequate size and pressure setting, as specified by the compressor manufacturer, to prevent rupture of the compressor or to prevent the pressure from increasing to more than 10% above the maximum allowable working pressure of any other component located in the discharge line between the compressor and the stop valve or in accordance with 9.7.5, whichever is larger. The pressure-relief device shall discharge into the low-pressure side of the system or in accordance with 9.7.8.

The relief device(s) shall be sized based on compressor flow at the following conditions:

1. **High-Stage or Single-Stage Compressors:** Flow is to be calculated based on 50°F (10°C) saturated suction temperature at the compressor suction.
2. **Low-Stage or Booster Compressors:** For those compressors that are capable of running only when discharging to the suction of a high-stage compressor, flow is to be calculated based on the saturated suction temperature equal to the design operating intermediate temperature.

Exception for items 1 and 2: The discharge capacity of the relief device is allowed to be the minimum regulated flow rate of the compressor when the following conditions are met:

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Table 4
Length ("L" in Feet) of Discharge Piping for Pressure-Relief Devices of Various Discharge Capacities

Rated Discharge Capacity, C_r # Air/Min[c]	Standard wall pipe, pipe size in inches[b]						Standard wall pipe, pipe size in inches[b]					
	½	¾	1	1¼	1½	2	½	¾	1	1¼	1½	2
	Relief Valve Setting 150 psig [a]						*Relief Valve Setting 200 psig* [a]					
5	68	276	(d)				115	470	(d)			
10	17	69	231				29	118	394			
15	7	31	102				13	52	175			
20	4	17	58	226			7	29	98			
25	3	11	37	145			5	19	63	248		
30	2	8	26	100	218		3	13	44	172		
40		4	14	57	122		2	7	25	97	210	
50		3	9	36	78	274		5	16	62	134	
60		2	6	25	54	190		3	11	43	93	
70			5	18	40	140		2	8	32	68	238
80			4	14	31	105		2	6	24	52	182
90			3	11	24	84			5	19	41	144
100			2	9	20	68			4	15	33	117
125				6	12	44			2	10	21	75
150				4	9	30				7	15	52
175				3	6	22				5	11	38
200				2	5	17				4	8	29
	Relief Valve Setting 250 psig [a]						*Relief Valve Setting 300 psig* [a]					
5	176		(d)				248		(d)			
10	44	179					62	254				
15	20	80	267				28	114				
20	11	45	150				15	54	212			
25	7	29	96				10	41	136			
30	5	20	67	263			7	28	94			
40	3	11	37	147			4	16	53	208		
50	2	7	24	94	204		3	10	34	134		
60		5	17	66	142		2	7	24	93	200	
70		4	12	48	104			5	17	68	147	
80		3	9	37	80			4	13	52	113	
90		2	7	29	63	220		3	10	41	89	
100		2	6	24	51	178		2	8	33	72	252
125			4	15	33	114		2	5	21	46	162
150			3	11	23	79			4	15	32	112
175			2	8	17	58			3	11	24	82
200			2	6	13	44			2	8	18	63
	Relief Valve Setting 350 psig [a]						*Relief Valve Setting 400 psig* [a]					
5	335		(d)				433		(d)			
10	84	380					108	492				
15	37	169					48	219				
20	21	95	285				27	123	369			
25	13	61	183				17	79	236			
30	9	42	127				12	55	164			
40	5	24	71	281			7	31	92	364		
50	3	15	46	180			4	20	59	233		
60	2	11	32	125	270		3	14	41	162	349	
70	2	8	23	92	198		2	10	30	119	257	
80		6	18	70	152		2	8	23	91	197	
90		5	14	56	120			6	18	72	155	
100		4	11	45	97	339		5	15	58	126	439
125		2	7	29	62	217		3	9	37	81	281
150		2	5	20	43	151		2	7	26	56	195
175			4	15	32	111		2	5	19	41	143
200			3	11	24	85			4	15	31	110

[a] To convert psig to kPa gage, multiply psig by 6.895.

[b] To convert inches to millimeters, multiply inches by 25.4.

[c] To convert # air/min to kg air/sec, multiply # air/min by 7.559×10^{-3}.

[d] To convert feet to meters, multiply feet by 0.3048.

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(a) the compressor is equipped with capacity regulation,

(b) capacity regulation actuates to minimum flow at 90% of the pressure-relief device setting, and

(c) a pressure-limiting device is installed and set in accordance with the requirements of 9.9.

Appendix F describes one acceptable method of calculating the discharge capacity of positive displacement compressor relief devices.

9.9 Pressure-Limiting Devices

9.9.1 When Required. Pressure-limiting devices shall be provided on all systems operating above atmospheric pressure, except that a pressure-limiting device is not required on any factory-sealed system containing less than 22 lb (10 kg) of Group A1 refrigerant that has been listed by an approved, nationally recognized testing laboratory and is so identified.

9.9.2 Setting. When required by 9.9.1, the maximum setting to which a pressure-limiting device is capable of being readily set by use of the adjusting means provided shall not exceed the design pressure of the highside of a system that is not protected by a pressure-relief device or 90% of the setting of the pressure-relief device installed on the highside of a system. The pressure-limiting device shall stop the action of the pressure-imposing element at a pressure no higher than this maximum setting.

Exception: On systems using nonpositive displacement compressors, the maximum setting of the pressure-limiting device is not required to be less than the design pressure of the highside of the system provided the pressure-relief device is (1) located in the lowside and (2) subject to lowside pressure and (3) there is a permanent (unvalved) relief path between the highside and the lowside of the system.

9.9.3 Connection. Pressure-limiting devices shall be connected between the pressure-imposing element and any stop valve on the discharge side. There shall be no intervening stop valves in the line leading to the pressure-limiting device.

9.10 Refrigerant Piping, Valves, Fittings, and Related Parts

9.10.1 Refrigerant piping, valves, fittings, and related parts having a maximum internal or external design pressure greater than 15 psig (103.4 kPa gage) shall be listed either individually or as part of an assembly or a system by an approved, nationally recognized laboratory or shall comply with *ASME B31.5*[15] where applicable.

9.10.2 Refrigerant Parts in Air Duct. Joints and all refrigerant-containing parts of a refrigerating system located in an air duct carrying conditioned air to and from an occupied space shall be constructed to withstand a temperature of 700°F (371.1°C) without leaking into the airstream.

9.11 Components Other Than Pressure Vessels and Piping

9.11.1 Every pressure-containing component of a refrigerating system, other than pressure vessels, piping, pressure gages, and control mechanisms, shall be listed either individually or as part of a complete refrigerating system or a subassembly by an approved, nationally recognized testing laboratory or shall be designed, constructed, and assembled to have an ultimate strength sufficient to withstand three times the design pressure for which it is rated.

Exception: Water-side components exempted from the rules of Section VIII of the *ASME Boiler and Pressure Vessel Code*[14] shall be designed, constructed, and assembled to have an ultimate strength sufficient to withstand 150 psig (1034 kPa) or two times the design pressure for which it is rated, whichever is greater.

9.11.2 Liquid-level-gage glass columns shall have automatic closing shut-off valves. All such glass columns shall be protected against external damage and properly supported.

Exception: Liquid-level-gage glasses of the bull's-eye type.

9.11.3 When a pressure gage is permanently installed on the highside of a refrigerating system, its dial shall be graduated to at least 1.2 times the design pressure.

9.11.4 Liquid receivers, if used, or parts of a system designed to receive the refrigerant charge during pumpdown shall have sufficient capacity to receive the pumpdown charge. The liquid shall not occupy more than 90% of the volume when the temperature of the refrigerant is 90°F (32°C).

Note: The receiver volume is not required to contain the total system charge but is required to contain the amount being transferred. If the environmental temperature is expected to rise above 122°F (50°C), the designer shall account for the specific expansion characteristics of the refrigerant.

9.12 Service Provisions

9.12.1 All serviceable components of refrigerating systems shall be safely accessible.

9.12.2 Access, including ladders, platforms, and clear space for inspection and servicing of condensing units, compressors, condensers, and other machinery, shall be provided in accordance with approved safety standards[5] and the requirements of the authority having jurisdiction.

9.12.3 Condensing units or compressor units with enclosures shall be readily accessible for servicing and inspection.

9.12.4 All systems shall have provisions to handle the refrigerant charge for service purposes. When required, there shall be liquid and vapor transfer valves, a transfer compressor or pump, and refrigerant storage tanks or appropriate valved connections for removal by a reclaim, recycle, or recovery device.

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9.12.5 Systems containing more than 6.6 lb (3 kg) of refrigerant shall have stop valves installed at the following locations:

(a) the suction inlet of each compressor, compressor unit, or condensing unit;
(b) the discharge of each compressor, compressor unit, or condensing unit; and
(c) the outlet of each liquid receiver.

Exceptions: Systems that have a refrigerant pumpout function capable of storing the entire refrigerant charge, or are equipped with the provisions for pumpout of the refrigerant, or self-contained systems.

9.12.6 Systems containing more than 110 lb (50 kg) of refrigerant shall have stop valves installed at the following locations:

(a) the suction inlet of each compressor, compressor unit, or condensing unit;
(b) the discharge outlet of each compressor, compressor unit, or condensing unit;
(c) the inlet of each liquid receiver, except for self-contained systems or where the receiver is an integral part of the condenser or condensing unit;
(d) the outlet of each liquid receiver; and
(e) the inlet and outlet of condensers when more than one condenser is used in parallel in the system.

Exceptions: Systems that have a refrigerant pumpout function capable of storing the entire refrigerant charge, or are equipped with the provisions for pumpout of the refrigerant, or self-contained systems.

9.12.7 Stop valves shall be suitably labeled if the components to and from which the valve regulates flow are not in view at the valve location. Valves or piping adjacent to the valves shall be identified[25] in accordance with *ANSI A13.1.*[20] When numbers are used to label the valves, there shall be a key to the numbers located within sight of the valves with letters at least 0.5 in. (12.7 mm) high.

9.13 Fabrication

9.13.1 The following are requirements for unprotected refrigerant-containing copper pipe or tubing:

(a) Copper tubing used for refrigerant piping shall conform to one of the following ASTM specifications: *B88-89*[16] types K or L or *B280-88.*[17] Where *ASTM B68-86*[18] and *B75-86*[19] tubing is used, the tube wall thickness shall meet or exceed the requirements of *ASTM B280-88*[17] for the given outside diameter.
(b) Copper tube shall be connected by brazed joints, soldered joints, or compression fittings.
(c) For groups A2, A3, B1, B2, and B3 refrigerants, protective metal enclosures shall be provided for annealed copper tube erected on the premises.

Exception: No enclosures shall be required for connections between a condensing unit and the nearest protected riser if such connections are not longer than 6.6 ft (2 m) in length.

9.13.2 Joints on refrigerant-containing copper tube that are made by the addition of filler metal shall be brazed.

Exception: A1 refrigerants.

9.14 Factory Tests

9.14.1 All refrigerant-containing parts or unit systems shall be tested and proved tight by the manufacturer at not less than the design pressure for which they are rated. Pressure vessels shall be tested in accordance with 9.3.

9.14.2 The test pressure applied to the highside of each factory-assembled refrigerating system shall be at least equal to the design pressure of the highside. The test pressure applied to the lowside of each factory-assembled refrigerating system shall be at least equal to the design pressure of the lowside.

The pressure test on the complete unit shall not be conducted at the lowside design pressure per 9.2 unless the final assembly connections are made per *ASME B31.5.*[15] In this case, parts shall be individually tested by either the unit manufacturer or the manufacturer of the part at not less than the highside design pressure.

9.14.3 Units with a design pressure of 15 psig (103.4 kPa gage) or less shall be tested at a pressure not less than 1.33 times the design pressure and shall be proved leak-tight at not less than the lowside design pressure.

9.15 Nameplate. Each unit system and each separate condensing unit, compressor, or compressor unit sold for field assembly in a refrigerating system shall carry a nameplate marked with the manufacturer's name, nationally registered trademark or trade name, identification number, the design pressures, and the refrigerant for which it is designed. The refrigerant shall be designated by the refrigerant number (R number) as shown in Table 1. If the refrigerant is not listed in Table 1, the refrigerant shall be designated in accordance with *ANSI/ASHRAE 34.*[4]

10. OPERATION AND TESTING

10.1 Field Tests

10.1.1 General

10.1.1.1 Every refrigerant-containing part of every system that is erected on the premises, except compressors, condensers, evaporators, safety devices, pressure gages, control mechanisms, and systems that are factory-tested, shall be tested and proved tight after complete installation and before operation.

The highside and lowside of each system shall be tested and proved tight at not less than the lower of the design pressure or the setting of the pressure-relief device protecting the highside or lowside of the system, respectively, except as noted in 10.1.1.2.

10.1.1.2 Systems erected on the premises using group A1 refrigerant and with copper tubing not exceeding 0.62 in. (16 mm) outside diameter shall be tested by means of the refrigerant charged into the system at the saturated vapor pressure of the refrigerant at 68°F (20°C) minimum.

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10.1.2 Testing Procedure. A suitable dry gas such as nitrogen or air shall be used for pressure testing.

The means used to build up the test pressure shall have either a pressure-limiting device or a pressure-reducing device with a pressure-relief device and a gage on the outlet side. The pressure-relief device shall be set above the test pressure but low enough to prevent permanent deformation of the system components.

10.1.3 Declaration. A dated declaration of test shall be provided for all systems containing 55 lb (25 kg) or more of refrigerant. The declaration shall give the name of the refrigerant and the field test pressure applied to the highside and the lowside of the system. The declaration of test shall be signed by the installer and, if an inspector is present at the tests, the inspector shall also sign the declaration. When requested, copies of this declaration shall be furnished to the authority having jurisdiction.

11. GENERAL REQUIREMENTS

11.1 Refrigerating Machinery Rooms. Access to the refrigerating machinery room shall be restricted to authorized personnel.

11.2 Signs and Identification

11.2.1 Installation Identification. Each refrigerating system erected on the premises shall be provided with a legible permanent sign, securely attached and easily accessible, indicating

(a) the name and address of the installer,
(b) the refrigerant number and amount of refrigerant,
(c) the lubricant identity and amount, and
(d) the field test pressure applied.

11.2.2 Controls and Piping Identification. Systems containing more than 110 lb (50 kg) of refrigerant shall be provided with durable signs having letters not less than 0.5 in. (12.7 mm) in height designating:

(a) valves or switches for controlling the refrigerant flow, the ventilation, and the refrigeration compressor(s), and
(b) the kind of refrigerant or secondary coolant contained in exposed piping outside the machinery room. Valves or piping adjacent to valves shall be identified[25] in accordance with *ANSI A13.1, Scheme for Identification of Piping Systems.*[20]

11.2.3 Changes in Refrigerant or Lubricant. When the kind of refrigerant or lubricant is changed as provided in 5.3, there shall be new signs to identify the changes in accordance with 11.2.1.

11.3 Charging, Withdrawal, and Disposition of Refrigerants. No service containers shall be left connected to a system except while charging or withdrawing refrigerant. Refrigerants withdrawn from refrigerating systems shall be transferred to approved containers only. Except for discharge of pressure-relief devices and fusible plugs, incidental releases due to leaks, purging of noncondensibles, draining oil, and other routine operating or maintenance procedures, no refrigerant shall be discharged to the atmosphere or to locations such as a sewer, river, stream, or lake.

11.4 Containers. Containers used for refrigerants withdrawn from a refrigerating system shall be as prescribed in the pertinent regulations of the Department of Transportation[21] and shall be carefully weighed each time they are used for this purpose, and containers shall not be filled in excess of the permissible filling weight.

11.5 Storing Refrigerant. The total amount of refrigerant stored in a machinery room in all containers not provided with relief valves and piping in accordance with 9.7 shall not exceed 330 lb (150 kg). Refrigerant shall be stored in approved storage containers.[21] Additional quantities of refrigerant shall be stored in an approved storage facility.

11.6 Self-Contained Breathing Apparatus (SCBA). When a machinery room is required per the rules of 7.4, at least one approved self-contained breathing apparatus, suitable for the refrigerant used, shall be located outside of, but close to, the machinery room. A second, backup, self-contained breathing apparatus shall also be provided.

11.7 Maintenance. Refrigerating systems shall be maintained by the user in a clean condition, free from accumulations of oily dirt, waste, and other debris, and shall be kept accessible at all times.

11.7.1 Stop Valves. Stop valves connecting refrigerant-containing parts to atmosphere during shipping, testing, operating, servicing, or standby conditions shall be capped, plugged, blanked, or locked closed when not in use.

11.7.2 Calibration of Pressure-Measuring Equipment. Pressure-measuring equipment shall be checked for accuracy and calibrated prior to test and immediately after every occasion of unusually high (full-scale) pressure, either by comparison with master gages or a dead-weight pressure gage tester, over the operating range of the equipment.

11.7.3 Periodic Tests. Detector(s), alarm(s), and mechanical ventilating systems shall be tested in accordance with manufacturers' specifications and the requirements of the jurisdiction having authority.

11.8 Responsibility for Operation and Emergency Shutdown. It shall be the duty of the person in charge of the premises on which a refrigerating system containing more than 55 lb (25 kg) of refrigerant is installed to provide a schematic drawing or panel giving directions for the operation of the system at a location that is convenient to the operators of the equipment.

Emergency shutdown procedures, including precautions to be observed in case of a breakdown or leak, shall be displayed on a conspicuous card located as near as possible to the refrigerant compressor. These precautions shall address

(a) instructions for shutting down the system in case of emergency;
(b) the name, address, and day and night telephone numbers for obtaining service; and
(c) the names, addresses, and telephone numbers of all corporate, local, state, and federal agencies to be contacted as required in the event of a reportable incident.

When a refrigerating machinery room is used, the emergency procedures shall be posted outside the room, immediately adjacent to each door.

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APPENDIX A

CALCULATIONS OF THE MAXIMUM ALLOWABLE CONCENTRATION (C_m) OF A BLEND

B1 For 100 lb of blend, determine the ideal gas volumes occupied by each component and by the blend at 70°F and 1 atm.

$$387\ W_1/(MW_1) = V_1 \quad V_T = V_1 + V_2 \ldots V_i$$

$$387\ W_2/(MW_2) = V_2$$

—

—

—

$$387\ W_i/(MW_i) = V_i$$

W_i = weight (lb) of component i in 100 lb of blend,

MW_i = molecular weight of component i,

V_i = volume (ft^3) of component i in 100 lb of blend at 70°F and 1 atm pressure,

V_T = volume (ft^3) of the blend at 70°F and 1 atm pressure.

B2 Determine the dilution volume required for the 100 lb of blend and each component therein.

$$V_1/LV_1 = DV_1$$

—

—

—

$$V_i/LV_i = DV_i$$

$$V_T/LV_{max} = DV_T$$

LV_i = (limiting volume percent from Table 1)/100,

DV_i = dilution volume required for weight (W_i) of component i,

LV_{max} = the highest value of LV_i.

B3 Determine the maximum allowable concentration (Cm) of a blend.

C_m = (100 lb/DV_{max})1000,

C_m = the maximum allowable concentration of blend lb/1000 ft^3 (multiply this value by 0.016 to obtain D_m in kg/m^3),

DV_{max} = the largest of the values DV_1, DV_2, DV_i, DV_T.

(This appendix is not part of this standard but is included for information purposes only.)

APPENDIX B

GUIDELINES FOR EMERGENCY DISCHARGE OF REFRIGERANTS WHEN REQUIRED BY LOCAL CODES

B1 Introduction

(a) Every precaution should be taken to prevent the accidental or deliberate discharge of refrigerants to the atmosphere, to the sewer, or into local lakes and rivers.

(b) Nevertheless, this appendix is provided to aid the design engineer where local codes require manual emergency discharge systems for refrigerants.

(c) It is permissible to use any departures suggested herein from provisions in the mandatory parts of this standard when granted by the authority having jurisdiction.

B2 Emergency Discharge Lines

An emergency discharge pipeline, independent of any other lines, shall be connected above the liquid refrigerant level on the high-pressure side and, when required by local codes, on the low-pressure side of the system. The lines shall be pitched so as to drain to the system. These lines shall extend into an emergency refrigerant control box. This box shall be locked and identified with a permanent label reading "Emergency Refrigerant Control Box" with the name of the refrigerant in the system.

B3 Stop Valves

A readily accessible stop valve and a suitable pressure gage shall be installed on the discharge pipe within the emergency refrigerant control box. The gage shall be located ahead of the stop valve, and the valve shall have the same capacity as the discharge pipe it serves. A permanent label shall be attached to the valve reading "High-Pressure Refrigerant Discharge Valve" or "Low-Pressure Refrigerant Discharge Valve" as appropriate.

B4 Sizing Valves and Lines

Determine the size of the discharge line and the stop valve from the required capacity per paragraph 9.7.5 and the length per paragraph 9.7.8.5.

B5 High- to Low-Pressure Valve

When both highside and lowside emergency discharge valves are located in a common box, a stop valve connecting them on the system side of the emergency discharge stop valves shall be provided in the box. The stop valve and line shall be the same size as the higher pressure line. This valve shall be labeled "High- to Low-Pressure Control Valve."

B6 Diffuser

The discharge line (B4) shall be vented to the atmosphere through a diffuser fitted to its upper extremity. The diffuser shall provide for mixing the refrigerant with air and shall

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have a rain cap or means to prevent water from easily entering the vent pipe.

B7 Sizing Headers and Diffusers

When more than one relief valve or emergency discharge line is connected to a common header or riser for discharge to the atmosphere, a diffuser shall be installed on the common riser. The area of the header or riser and the diffuser inlet shall be equal to the sum of the areas of all of the relief valve vent lines and emergency discharge lines feeding it.

B8 Location of Diffuser

The diffuser shall be located per paragraph 9.7.8 for discharge to the atmosphere.

B9 Provide Drip Legs

Adequately sized drip pockets for collecting moisture shall be installed on every emergency line beyond the emergency valve exposed to the atmosphere.

B10 Ammonia Diffusion Systems

Ammonia may be released from refrigerating systems to the atmosphere in the event of an emergency. If this is done by employees of the refrigerated facility, it may be subject to the reporting requirements of the Emergency Planning and Community Right-to-Know Act of 1986. In locations where atmospheric release may be hazardous due to the proximity of people or other premises, the diffuser shall be equipped with an automatic burner for reducing the discharge to nitrogen and water, or such emergency system shall discharge into a storage tank (per paragraph 9.7.8.2) or into a water mixer (B15) and retention tank (B13) or basin (B14).

B11 Ammonia Discharge Lines

For emergency discharge line connections to the system, the stop valves and control box shall be as described above.

B12 Ammonia Flares

Systems for reducing the ammonia to nitrogen and water by burning shall be approved by the jurisdictional authority.

B13 Water Tanks

Water tanks shall be as specified in 9.7.8.2.

B14 Basins

Retention basins shall meet the requirements as set forth by the fire chief in the local jurisdiction.

B15 Ammonia-Water Mixers

Ammonia-water mixers shall have the following components:

(a) Connection to a permanent water supply with a capacity as in (c).

(b) A fire department inlet hose connection to the diffuser adjacent to the Emergency Refrigeration Control Box.

(c) An engineered ammonia-water mixing chamber, sized to provide 2 gpm of water per lb/min of ammonia (17 L/s water per kg/s ammonia). The ammonia flow can be estimated at 77% of the equivalent airflow calculated for the discharge line from 9.7.5 and 9.7.8.5.

(d) Connection to an approved storage tank, basin, or drainage system by means of welded or flanged piping.

(e) Necessary control valves, check valves, and fittings.

B16 Design Responsibility

The design of the manual emergency discharging system and the components that comprise it, such as the diffusers for mixing refrigerants with air or water, as well as the design of tanks and holding basins, is the responsibility of the engineer.

(This appendix is part of this standard and is required for its use.)

APPENDIX C

WORST-CASE COMPOSITION OF FRACTIONATION

Since fractionation of zeotropic blends (R-400 series refrigerants) occurs as the result of a system leak, both the fractionation of the blend remaining in the system and the composition of the blend leaking into the machinery room or equipment space shall be considered when determining "worst-case composition." The phrase "worst-case composition of fractionation" is to be defined as the composition, either as formulated or at a composition that occurs during fractionation, that for flammability results in the highest concentration of the flammable component(s) in either the vapor or liquid phase and for toxicity results in the highest concentration of the toxic component(s) in either the vapor or liquid phase.

The worst-case composition for toxicity shall be considered independently of the worst-case composition for flammability.

The toxicity of blends must be defined according to Appendix C of the ACGIH manual of *Threshold Limit Values*. The basic formula is as follows:

$$TLV = \frac{1}{\frac{\text{mol frac A}}{TLV\,\text{A}} + \frac{\text{mol frac B}}{TLV\,\text{B}} + \frac{\text{mol frac C}}{TLV\,\text{C}}\ \text{etc.}}$$

(This appendix is not part of this standard but is included for information purposes only.)

APPENDIX D

INFORMATIVE REFERENCES

This appendix contains full citations for informative references only. Full citations for normative references are listed in Appendix E. References in this standard are numbered in the order in which they appear in the document, so the numbers for the normative references are shown for the convenience of the user.

1. *NIOSH Pocket Guide to Chemical Hazards* (1985), U.S. Department of Health and Human Services, Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. (IDLH definition.)

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2. Not an informative reference.

3. *ACGIH Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* (1990-1991), American Conference of Governmental and Industrial Hygienists, Cincinnati, OH.

4. *ANSI/ASHRAE 34-1992, Designation and Safety Classification of Refrigerants*, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA 30329.

   Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users this reference is informative.*

5. *ANSI/NFPA 101-1988, Code for Safety to Life from Fire in Buildings and Structures*, National Fire Protection Association (NFPA), Quincy, MA 02269.

6. *ANSI/ASME B15.1-1984, Safety Code for Mechanical Power Transmission Apparatus*, and *Addendum B15.1-A-1986*, American Society of Mechanical Engineers (ASME), New York, NY 10017.

   Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users this reference is informative.*

7. *ANSI/UL 303-1987, Refrigeration and Air-Conditioning Condensing and Compressor Units*, Underwriters Laboratories, Inc., Northbrook, IL 60062.

   Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users this reference is informative.*

8. *ANSI/IES RP-7-1983, Practice for Industrial Lighting*, Illuminating Engineering Society of North America (IES), New York, NY 10017.

   Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users this reference is informative.*

9. Not an informative reference.

10. *NFPA Standard 54-1988 (ANSI Z223.1-1988), National Fuel Gas Code*, National Fire Protection Association (NFPA), Quincy, MA 02269.

    Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users this reference is informative.*

11. *ANSI/NFPA 37-1990, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, National Fire Protection Association (NFPA), Quincy, MA 02269.

    Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users this reference is informative.*

12. *ANSI/NFPA 90A-1989, Standard for the Installation of Air Conditioning and Ventilating Systems*, National Fire Protection Association (NFPA), Quincy, MA 02269.

    Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users this reference is informative.*

13. *ANSI/NFPA 90B-1989, Standard for the Installation of Warm Air Heating and Air Conditioning Systems*, National Fire Protection Association (NFPA), Quincy, MA 02269.

    Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users this reference is informative.*

14. *ASME Boiler and Pressure Vessel Code*, Section VIII, Rules for Construction of Pressure Vessels, Division 1, 1992, American Society of Mechanical Engineers (ASME), New York, NY 10017.

    Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users this reference is informative.*

15. *ASME/ANSI B31.5-1987, Refrigeration Piping, and Addendum B31.5A-1989*, American Society of Mechanical Engineers (ASME), New York, NY 10017.

    Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users this reference is informative.*

16. Not an informative reference.

17. Not an informative reference.

18. Not an informative reference.

19. Not an informative reference.

20. Not an informative reference.

21. U.S. Department of Transportation Code of Federal Regulations 49, TRANSPORTATION, Parts 100-199, "Regulations for Transportation of Explosive and Other Dangerous Articles by Land and Water in Rail Freight Service and by Motor Vehicle (Highway) and Water, Including Specifications for Shipping Containers." Revised at least once each calendar year and issued as of October 1. U.S. Department of Transportation (DOT), Office of Hazardous Materials, Transportation, Washington, DC 20590.

    Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users this reference is informative.*

22. *NFPA 68-1988, Guide for Venting of Deflagrations*, National Fire Protection Association (NFPA), Quincy,

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23. USAF Facility Design and Planning, *Engineering Weather Data*, AFM 88-29, Department of the Air Force, the Army, and the Navy, Washington, DC.

24. *ASHRAE Handbook of Fundamentals*, 1993.

25. *IIAR Bulletin 114, 9/91, Guidelines for Identification of Ammonia Refrigeration Piping and System Components*, International Institute of Ammonia Refrigeration, 1101 Connecticut Ave, N.W., Washington, DC 20036.

(This appendix is part of this standard and is required for its use.)

APPENDIX E

NORMATIVE REFERENCES

This appendix contains full citations for normative references. Full citations for references that are solely informative are included in Appendix D. Note that in some locations within the standard, normative references are also used as informative references. References in this standard are numbered in the order in which they appear in the document, so the numbers for the informative references are shown for the convenience of the user.

1. Not a normative reference.

2. *ASTM D93-85, Standard Test Methods for Flash Point by Pensky-Martens Closed Tester*, American Society for Testing and Materials (ASTM), Philadelphia, PA 19103.

3. Not a normative reference.

4. *ANSI/ASHRAE 34-1992, Designation and Safety Classification of Refrigerants*, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA 30329.

   Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users, this reference is informative.*

5. Not a normative reference.

6. *ANSI/ASME B15.1-1984, Safety Code for Mechanical Power Transmission Apparatus, and Addendum B15.1-A-1986*, American Society of Mechanical Engineers (ASME), New York, NY 10017.

   Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users, this reference is informative.*

7. *ANSI/UL 303-1987, Refrigeration and Air-Conditioning Condensing and Compressor Units*, Underwriters Laboratories, Inc., Northbrook, IL 60062.

   Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users, this reference is informative.*

8. *ANSI/IES RP-7-1983, Practice for Industrial Lighting*, Illuminating Engineering Society of North America (IESNA), New York, NY 10017.

   Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users, this reference is informative.*

9. *ANSI/NFPA 70-1990, National Electrical Code*, National Fire Protection Association (NFPA), Quincy, MA 02269.

10. *NFPA Standard 54-1988 (ANSI Z223.1-1988), National Fuel Gas Code*, National Fire Protection Association (NFPA), Quincy, MA 02269.

    Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users, this reference is informative.*

11. *ANSI/NFPA 37-1990, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, National Fire Protection Association (NFPA), Quincy, MA 02269.

    Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users, this reference is informative.*

12. *ANSI/NFPA 90A-1989, Standard for the Installation of Air Conditioning and Ventilating Systems*, National Fire Protection Association (NFPA), Quincy, MA 02269.

    Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users, this reference is informative.*

13. *ANSI/NFPA 90B-1989, Standard for the Installation of Warm Air Heating and Air Conditioning Systems*, National Fire Protection Association (NFPA), Quincy, MA 02269.

    Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users, this reference is informative.*

14. *ASME Boiler and Pressure Vessel Code*, Section VIII, Rules for Construction of Pressure Vessels, Division 1, 1992, American Society of Mechanical Engineers (ASME), New York, NY 10017.

    Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users, this reference is informative.*

15. *ASME/ANSI B31.5-1987, Refrigeration Piping, and Addendum B31.5A-1989*, American Society of Mechanical Engineers (ASME), New York, NY 10017.

    Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration*

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equipment. For all other users, this reference is informative.

16. *ANSI/ASTM B88-89, Standard Specification for Seamless Copper Water Tube*, American Society for Testing and Materials (ASTM), Philadelphia, PA 19103.

17. *ANSI/ASTM B280-88, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service*, American Society for Testing and Materials (ASTM), Philadelphia, PA 19103.

18. *ASTM B68-86, Standard Specification for Seamless Copper Tube, Bright Annealed*, American Society for Testing and Materials (ASTM), Philadelphia, PA 19103.

19. *ASTM B75-86, Standard Specification for Seamless Copper Tube*, American Society for Testing and Materials (ASTM), Philadelphia, PA 19103.

20. *ANSI A13.1-1981 (R1985), Scheme for the Identification of Piping Systems*, American Society of Mechanical Engineers (ASME), New York, NY 10017.

21. U.S. Department of Transportation, *Code of Federal Regulations* 49, TRANSPORTATION, Parts 100-199, "Regulations for Transportation of Explosive and Other Dangerous Articles by Land and Water in Rail Freight Service and by Motor Vehicle (Highway) and Water, Including Specifications for Shipping Containers." Revised at least once each calendar year and issued as of October 1. U.S. Department of Transportation (DOT), Office of Hazardous Materials, Transportation, Washington, DC 20590.

    Note: *This reference is mandatory for designers, manufacturers, and producers of refrigeration equipment. For all other users, this reference is informative.*

22. Not a normative reference.

23. Not a normative reference.

24. Not a normative reference.

25. Not a normative reference.

(This appendix is not part of this standard but is included for information purposes only.)

APPENDIX F

METHOD FOR CALCULATING DISCHARGE CAPACITY OF POSITIVE DISPLACEMENT COMPRESSOR PRESSURE-RELIEF DEVICE

The following calculation method provides the required discharge capacity of the compressor pressure-relief device in 9.8:

$$W_r = Q\,\eta_v / v_g \qquad \text{(F-1)}$$

where

W_r = mass flow of refrigerant, lb/min (kg/s);
Q = swept volume of compressor, ft^3/min (m^3/s);
η_v = volumetric efficiency (assume 0.9 unless actual volumetric efficiency at relieving pressure is known);
v_g = specific volume of refrigerant vapor as specified in 9.8.

Next, find the relieving capacity in mass flow of air, W_a, for ASME-rated (Reference 14) pressure-relief devices:

$$W_r = W_r r_w \qquad \text{(F-2)}$$

where

$$r_w = \frac{C_a}{C_r}\sqrt{\frac{T_r}{T_a}}\sqrt{\frac{M_a}{M_r}} \qquad \text{(F-2a)}$$

M_r = molecular mass of refrigerant,
M_a = molecular mass of air = 28.97,
T_a = absolute temperature of the air = 520 R,
C_a = constant for air = 356, and
T_r = absolute temperature of refrigerant = 510 R.

$$C_r = 520\sqrt{k\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}} \qquad \text{(F-2b)}$$

where

k = specific heat ratio = c_p/c_v,
C_p = specific heat of refrigerant at constant pressure, and
C_v = specific heat of refrigerant at constant volume.

Constants for several refrigerants are listed below:

Refrigerant Number	k	Molecular Mass	C_r	r_w
R-12	1.22	120.93	339.2	0.51
R-22	1.32	86.48	348.9	0.58
R-134a	1.19	102.03	336.2	0.56
R-500	1.19	99.31	336.2	0.57
R-502	1.26	111.63	320.1	0.52
R-290	1.24	44.10	341.2	0.84
R-717	1.30	17.03	347.0	1.33

Example: Determine the flow capacity of a relief device for an ammonia (R-717) screw compressor with a swept volume, Q, of 1,667 ft^3/min.

η_v = 0.90, assumed
v_g = 3.2997 ft^3/lb
W_r = 1667(0.90)/3.2997 = 454.68 lb/min of ammonia (see F-1)
W_a = $W_r r_w$ (see F-2)
= 454.68(1.33) = 604.7 lb/min.

Converting to standard cubic feet per minute (scfm),

where

V_a = specific volume of air
= 13.1 ft^3/lb for dry air at 60°F,
scfm= 13.1(604.7) = 7,922 ft^3/min.

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APPENDIX G

This table cross-references only related paragraphs and does not indicate if any changes or additions were made to the original paragraph.

Paragraph Number Comparison of ASHRAE 15-1992 with ASHRAE 15-1994

15-1992	15-1994	15-1992	15-1994	15-1992	15-1994	15-1992	15-1994
none	4.1.5	7.4.2	same	9.3	9.9.3	11.6	8.6
none	7.2	8	9	10	9.4	11.7	8.7
none	8.13.7	8.1	9.1	10.1.1	9.4.1	11.8	8.8
1	same	8.1.1	9.1.1	10.1.2	9.4.2	11.9	8.9
2	same	8.1.2	9.1.2	10.1.3	9.4.3	11.10	8.10
2.1	same	8.1.3	9.1.3	10.1.4	9.4.4	11.10	9.10.2
2.2	same	8.1.4	9.1.4	10.1.5	9.4.5	11.11	8.11
2.3	same	8.2	9.2	10.1.6	9.4.6	11.12	8.12
2.4	same	8.2.1	9.2.1	10.1.6	9.4.7	11.12.1	8.12.1
2.5	same	8.2.1.1	9.2.1.1	10.1.7	9.4.8	11.12.2	8.12.2
3	same	8.2.1.2	9.2.1.2	10.1.8	9.4.9	11.12.3	8.12.3
4	same	8.2.1.3	9.2.1.3	10.2	9.5	11.12.4	8.12.4
4.1	same	8.2.2	9.2.2	10.2.1	9.5.1	11.13	8.13
4.1.1	same	8.2.3	9.2.3	10.2.2	9.5.2	11.13.1	8.13.1
4.1.2	same	8.2.4	9.2.4	10.3	9.6	11.13.2	8.13.2
4.1.3	same	8.2.5	9.2.5	10.3.1	9.6.1	11.13.2.2	8.13.2
4.1.4	same	8.3	9.3	10.3.2	9.6.2	11.13.3	8.13.3
4.1.5	4.1.6	8.3.1	9.3.1	10.3.3	9.6.3	11.13.4	8.13.4
4.1.6	4.1.7	8.3.1.1	9.3.1.1	10.4	9.7	11.13.5	8.13.6
4.2	same	8.3.1.2	9.3.1.2	10.4.1	9.7.1	11.13.7	8.13.5
5	same	8.3.1.3	9.3.1.3	10.4.2	9.7.2	11.14	8.14
5.1	same	8.3.2	9.3.2	10.4.2.1	9.7.2.1	11.15	8.15
5.1.1	same	8.3.3	9.3.3	10.4.2.2	9.7.2.2	11.16	8.16
5.1.2	same	8.4	9.10	10.4.2.3	9.7.2.3	12	10.1
5.1.2.1	same	8.4.1.1	9.10.1	10.4.2.3	9.7.2.4	12.1	10.1.1
5.1.2.2	same	8.4.1.2	9.13.1	10.4.3	9.7.3	12.1.1	10.1.1.1
5.1.2.3	same	8.4.2.1	9.13.1 Exception	10.4.4	9.7.4	12.1.2	10.1.1.2
5.1.2.4	same	8.4.2.2	9.13.2	10.4.5	9.7.5	12.2	10.1.2
5.2	same	8.5	9.11	10.4.6	9.7.6	12.3	10.1.3
5.2.1	same	8.5.1	9.11.1	10.4.7	9.7.7	13	11
5.2.2	same	8.5.2	9.11.2	10.4.8	9.7.8	13.1	11.2
6	same	8.5.3	9.11.3	10.4.8.1	9.7.8.1	13.1.1	11.2.1
6.1	same	8.5.4	9.11.4	10.4.8.2	9.7.8.2	13.1.2	11.2.2
6.2	same	8.6	9.12	10.4.8.3	9.7.8.3	13.1.3	11.2.3
7	same	8.6.1	9.12.1	10.4.8.4	9.7.8.4	13.2	5.3
7.1	same	8.6.2	9.12.4	10.4.8.5	9.7.8.5	13.3	11.3
7.2	7.3	8.6.3	9.12.5	10.5	9.8	13.4	11.3
7.2.1	7.3.1	8.7	9.14	11	8	13.5	11.4
7.2.2	7.3.2	8.7.1	9.14.1	11.1	8.1	13.6	11.5
7.2.3	7.3.3	8.7.2	9.14.2	11.2	8.2	13.7	11.6
7.2.4	7.3.4	8.7.3	9.14.3	11.3	8.3	13.8	11.7
7.2.5	7.3.5	8.8	9.15	11.3	9.12.2	13.9	11.8
7.3	7.2	9	9.9	11.4	8.4		
7.4	same	9.1	9.9.1	11.4	9.12.3		
7.4.1	same	9.2	9.9.2	11.5	8.5		

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POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effects on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

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